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An Assessment of Newfoundland and Labrador Snow Crab (*Chionoecetes opilio*) in 2007

Évaluation du crabe des neiges (*Chionoecetes opilio*) de Terre-Neuve-et-Labrador en 2007

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ABSTRACT

Resource status was evaluated throughout Northwest Atlantic Fisheries Organization (NAFO) Div. 2J3KLNOP4R based on trends in biomass, recruitment and mortality. Multiple indices of these metrics were derived from a suite of data sources that include dockside-monitored landings, fisher logbooks, observer monitoring, pre-and post-season trawl surveys, broad-scale post-season trap surveys, localized inshore trap surveys, a vessel monitoring system (VMS) and biological sampling data from multiple sources. The resource was assessed separately for offshore and inshore areas of each NAFO division, where appropriate (Div. 3KLPs4R3Pn). Data availability varied among divisions and between inshore and offshore areas within divisions. Data were insufficient to evaluate resource status in Div. 3NO and in offshore Div. 4R3Pn. The exploitable biomass has recently increased in the north (Div. 2J3K) due to increased recruitment. The exploitable biomass has declined and remains low in the south (offshore Div. 3L and Subdiv. 3Ps), but recruitment is expected to increase in the near future. The exploitable biomass has recently increased in inshore Div. 3L whereas it has declined in inshore Div. 4R3Pn and recruitment prospects are uncertain or unknown. Trends in indices are described in detail for each division and conclusions are presented with respect to the anticipated effects of short term changes in removal levels on fishery induced mortality.

RÉSUMÉ

On a évalué l'état de la ressource à l'échelle des divisions 2J3KLNOP4R de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO) d'après les tendances relatives à la biomasse, les perspectives de recrutement et de mortalité. Plusieurs indices de ces paramètres ont été tirés d'un ensemble de sources de données comprenant les débarquements vérifiés à quai, les journaux de bord des pêcheurs, la surveillance par des observateurs, les relevés au chalut de fond pré- et post-saison, les relevés au casier réalisés à grande échelle en fin de saison, les relevés au casier réalisés à petite échelle dans les eaux côtières, un système de surveillance des navires ainsi que les données d'échantillonnage biologique provenant de sources multiples. La ressource a été évaluée séparément pour les zones extracôtières et côtières de chaque division de l'OPANO, le cas échéant (divisions 3KLPs4R3Pn). La disponibilité des données variait selon les divisions et entre les zones côtières et extracôtières au sein des divisions. Les données étaient insuffisantes pour évaluer l'état de la ressource dans la division 3NO et dans les divisions extracôtières 4R3Pn. La biomasse exploitable a augmenté récemment dans le nord (divisions 2J3K) en raison de l'augmentation du recrutement; cependant, l'indice a connu un déclin et demeure faible dans le sud (division extracôtière 3L et sous-division 3Ps), mais on y prévoit un regain de recrutement dans un avenir rapproché. L'indice de biomasse exploitable a enregistré une hausse récemment dans la division côtière 3L, tandis qu'il a enregistré un déclin dans les divisions côtières 4R3Pn et les perspectives de recrutement sont incertaines ou inconnues. Les tendances concernant les indices sont décrites en détail pour chacune des divisions, et les conclusions sont présentées relativement aux effets prévus des changements à court terme des niveaux de prises sur la mortalité par la pêche.

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 but increases have occurred in the northern Divisions (Dawe et al. 2008). 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 2007. Data from the multi-species bottom trawl surveys, conducted during fall in Div. 2J3KLNO and during spring in Subdiv. 3Ps are presented to provide information on trends in biomass, recruitment, production, and mortality over the time series. The fall survey data have been used in annual snow crab assessments since 1997 (Dawe et al. 2008). Multi-species survey indices are compared with other relevant indices derived from fisher logbook data, observer data, VMS and dockside monitoring data, and inshore and offshore Div. 3KLPs4R trap survey data, toward inferring changes in resource status for 2008 and beyond.

METHODOLOGY

MULTI-SPECIES SURVEY DATA

Data on total catch numbers and weight were acquired from the 1995-2007 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 1996-2007 were available for Div. 3LNOPs. Data from spring surveys had previously been considered unreliable, but a recent analysis of a more extended time series has shown that they provide useful assessment indices (Mullowney et al. 2008). Sampling from spring surveys was exclusive to Subdiv. 3Ps from 1996 to 1998 but was expanded to incorporate Div. 3LNO in 1999. These surveys utilized the same gear and methods as detailed for fall surveys. A set of strata common to all years was selected for analysis, and similar to the fall survey series, it does not include inshore or deep strata. The 2006 Div. 3NOPs survey was incomplete and has been omitted from analyses. In divisions where both a spring and a fall survey are conducted (Div. 3LNO), only data from fall surveys are used in this assessment. Fall surveys have been shown to have higher catch rates of crab than spring surveys (Mullowney et al. 2008) and indices derived from the fall survey have historically been used to assess the resource.

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 carapace width (CW, mm) and shell condition was assigned one of four categories: (1) soft-shelled – These crabs had recently molted, have a high water content and are not retained in the fishery; (2) new-shelled - these crabs 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; (3) intermediate-shelled – these crab last molted in the previous year and are fully recruited to the fishery throughout the current fishing season; (4) 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 fishing 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 biomass indices of legal-sized males, by shell condition toward evaluating the internal consistency of the data series. Males enter the legal-size group as soft-shelled crabs, after the spring molt and remain as new-shelled for the duration of the current year's fishery. They begin to contribute to the legal-sized intermediate-shelled group in the following year. Hence we would expect annual changes in biomass to be first seen in soft or new-shelled legal-sized males and to be followed by similar trends in intermediate and subsequently old-shelled males.

Indices were calculated from spring and fall surveys using STRAP (Smith and Somerton 1981), to represent the exploitable biomass and pre-recruit biomass. For spring (pre-season) surveys, these indices represent biomass for the immediately upcoming fishery in the current year whereas for fall (post-season) surveys the indices represent biomass for the next fishery in the following year. The exploitable biomass index was calculated as the survey biomass index of adult (large-clawed) legal-sized (>94 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 exploitable biomass index generated from spring survey data includes a component of new-shelled males that would not actually be retained by the fishery in the immediately upcoming fishery but 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 surveys, before applying STRAP. The resultant pre-recruit index, from fall surveys, represents a component of legal-sized (>94 mm CW) males that would be recently-molted, (soft or 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 intermediate-shelled males, one additional year later (i.e. 3 years after the fall 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. 2002). 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. For each survey series, biomass indices are comparable among years because only those survey strata common among all years were included in the analysis. Inshore survey strata were not included in calculating biomass indices because they were not surveyed in some years.

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

The ratio of the annual landings to the exploitable biomass index (projected from the fall survey of the previous year) was calculated by NAFO Division to provide an index of exploitation rate. This index overestimates 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, spring and fall survey catches by CW 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 Fisheries and Oceans Canada. Catch per unit of effort (CPUE, kg/trap haul) was calculated by year and NAFO Division. CPUE is used as an index of biomass, but it is unstandardized in that it does not account for variation in fishing practices (e.g. 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 (Fig. 1). Annual offshore values, for recent years, are also used 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.

The spatial extent of annual fishing effort for inshore and offshore areas of each NAFO Division was calculated from commercial logbooks. Sets were assigned to 5' x 5' cells based on logbook co-ordinates. The annual ratio of the total number of cells with fishing effort (≥1 set) to the total number of cells in each area was used as an index of spatial expansion or contraction and compared with trends in fishery CPUE.

OBSERVER CATCH-EFFORT DATA

Set and catch data were available from the Observer Program for the same time series as those from the multispecies surveys (1995-2007), but at-sea sampling data have only been collected since 1999. 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 inshore and offshore logbook CPUE.

For offshore areas, 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. Pre-recruit biomass index (PBI) (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 overestimates 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. In both inshore and offshore areas, 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, since 1999, 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 trawl surveys, in that categories of crabs not recently molted (intermediate-shelled and old-shelled in trawl surveys) were pooled into a single category. These biological sampling data were used to identify specific categories of discards (i.e. 'undersized' and 'soft' legal-sized) for comparison with total discards from observer set-and-catch data. Also seasonal trends in the percentage of soft-shelled crabs were described. Discarding is believed to impose a high mortality on recently-molted (especially 'soft') immediate pre-recruits. A soft-shell protocol was implemented in 2004 to close specific small fishing areas when the percentage of soft-shell crab reached 20%.

VESSEL MONITORING SYSTEM (VMS) AND DOCKSIDE MONITORING PROGRAM (DMP) DATA

Data on hourly vessel positions (VMS) and landed catch (DMP) were obtained from the Fisheries Management Branch and the Policy and Economics Branch, Statistics Division, Newfoundland Region of Fisheries and Oceans Canada. These datasets were merged based on vessel registration number (VRN), year, month, and day. A CPUE index (kg/fishing hr) was calculated by year and NAFO Division, as described by Mullowney and Dawe (2008). Fishing hours were screened based on location and speed from hourly positional signals. Signals occurring out of port at 0.1–3.0 knot speeds were accepted as fishing signals. The VMS dataset consisted of a short (four year) time series and was limited to offshore fishing fleets.

VMS-based 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 vessel drift). Trends in VMS-based CPUE are presented as a fishery-based index of trends in biomass for offshore areas and compared with commercial logbook and observer-based CPUE indices.

TRAP SURVEYS

Data were available from an inshore Div. 3K trapping survey that was carried out in White Bay and Notre Dame Bay during 1994-2007, with the exception of 2001. The survey has consistently been conducted in September and it occupies 5 of the inshore fall multi-species 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 two inshore trap surveys (1979-2006) within Div. 3L. These surveys were conducted in different seasons; summer (Bonavista Bay), and fall (Conception Bay). For each survey series, catch rate indices and size distributions were produced as described above for the inshore Div. 3K trapping surveys.

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 examined for the first time in 2006 (Dawe et al. 2008). They were initiated following the 2003 fishery and have been conducted annually thereafter, beginning September 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 a 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. 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 from spring through fall. Until the early 1980's, the fishery was prosecuted by approximately 50 vessels limited to 800 traps each. In 1981, fishing was restricted to the NAFO Division where the licence holder resided. During 1982-87, there were major declines in the resource in traditional areas in Div. 3K and 3L while new fisheries started in Div. 2J, Subdiv. 3Ps and offshore Div. 3K. Since the late 1980's, the resource has increased in these areas. A snow crab fishery began in Div. 4R in 1993.

Licences supplemental to groundfishing were issued in Div. 3K and Subdiv. 3Ps in 1985, in Div. 3L in 1987, and in Div. 2J in the early 1990's. Since 1989, there has been a further expansion in the offshore. Temporary permits for inshore vessels <35 ft, introduced in 1995, were converted to licences in 2003. There are now several fleet sectors and about 3350 licence holders. In the late 1980's, quota control was initiated in all management areas (Fig. 1) of each division. All fleets have designated trap limits, quotas, trip limits, fishing areas within divisions, and differing seasons. Mandatory use of the electronic 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 55,600 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 Division 3K, where the reduced TAC was not taken. In 2006, landings increased to 47,000 t, and they further increased to 50,000 t in 2007, predominately due to increases in Div. 3K. 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), but there has been a reduction in effort along the shelf slope in Divs. 2J3KNOPs since 2003 (Dawe et al. 2004). In 2007, there was little effort along the shelf edge of Div. 3O (Fig. 4) relative to previous years (Dawe et al. 2008).

DIVISION 2J3KLNOPs

Spatial distribution from fall multi-species surveys (Division 2J3KLNO)

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 2007 was generally similar to the distribution pattern observed throughout 1997-2006, as previously described (Dawe et al. 2008, Dawe and Colbourne 2002) with some exceptions. Large males have consistently been virtually absent over a broad area of the shallow (<100 m) southern Grand Bank throughout the time series. In 2007, abundance of largest males was also low in the deepest sets (>500 m) along the Div. 2J3KLNO slope (Fig. 5), relative to previous years. Compared to 2006, survey catches of exploitable males in 2007 were similar in Div. 2J3LO, higher in the northern portions of Div 3K offshore, but lower in Div. 3N. Survey catches of pre-recruit males (Fig. 6) in 2007 were higher in the southern divisions (Div. 3LNO) but lower in the northern divisions (Div. 2J3K) compared to 2006.

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 of 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 trawl surveys in Div. 2J3KLNO indicate a decline in exploitable biomass from 1998 to 2003 (Fig. 7). The more limited time series from spring trawl surveys in Div. 3LNOPs also indicated a decline in exploitable biomass, from 1999 to 2004 (Fig. 8). Both spring and fall surveys indicate that the exploitable biomass and abundance remained low during 2003-06 but increased in 2007.

Recruitment

Both the spring and fall multispecies surveys indicate that recruitment prospects deteriorated to 2002 and remained poor to 2005 (Fig. 9-10). Pre-recruit abundance and biomass increased from 2005 to 2007 according to both survey series.

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 surveys, whereas the pre-recruit index includes a large component of males that were adolescents as small as 76 mm CW during the surveys. 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, 2008) 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. 2008) 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 (Dawe et al. 2008). The model (Fig. 11) predicted 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

Bitter Crab Disease (BCD) has been observed in snow crab, based on macroscopic observations, at low levels throughout 1996-2007. 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).

There had been a broadly-distributed incidence of bitter crab disease during 1996-2006, but the distribution has become limited to localized aggregations, primarily to Div. 3K and 3L in 2007 (Fig. 12). This disease, which is fatal to crabs, occurs in new-shelled crab of both sexes and appears to be acquired during molting (Dawe 2002). Prevalence has decreased in 2007.

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 (Table 2, Fig. 13) peaked in 1999 at 5400 t, decreased sharply to 3700 t in 2000 and changed little to 2002. They declined from 2002 to 2005 and then increased by 53% to 2330 t in 2007. Effort increased to a record high level in 2002-2004. It declined by more than half from 2004 to 2006 before increasing by 12% in 2007. Commercial CPUE (Table 2, Fig. 14) indicates the fishery performance has improved since 2004.

The 2007 fishery was concentrated in Hawke and Cartwright Channels, similar to in 2006 (Fig. 15). In 2006-07 there was no fishery on the slope as there was in 2002-05.

Effect of ocean climate variability

Bottom temperature in Div. 2J has been inversely related to commercial CPUE, at a seven-year lag since 1984 (Fig. 16). Since 2004 however, CPUE has increased considerably while the lagged bottom temperature has remained high. This substantial improvement in fishery performance is not entirely due to change in the exploitable biomass, but is also partly due to the reduction in fishery removals during 1999-2005 (Fig. 13). However it likely also reflects increased biomass which may be due to a general trend toward earlier fishing seasons since 2003 (Dawe et al. 2008), and reduced fishing effort since 2004 (Fig. 13) which jointly resulted in reduced fishing mortality on soft-shelled pre-recruits.

Biomass

Commercial catch rates (CPUE) have oscillated over the time series (Table 2, Fig. 14). CPUE has increased from its lowest level in 2004 to about the long-term average in 2007. The increase in CPUE in recent years can be attributed to improved catch rates in and around Cartwright Channel in the north and Hawke Channel in the south (Fig. 15).

The commercial logbook, observer, and VMS CPUE indices all increased since 2004 (Fig. 17). However the increase in 2007 was smaller for the logbook index than that for the other two indices. This may be somehow related to a greater contribution by small vessels to the logbook datasets than to the other datasets. VMS is exclusive to larger, offshore vessels and observer coverage is generally higher on larger vessels. However it is unknown whether small vessels performed especially poorly in 2007 relative to larger vessels.

The spatial coverage of the fishery has been inversely related to commercial CPUE (Fig. 18). The percentage of available 5' x 5' cells occupied by the fishery declined abruptly from its highest level of 19% in 2004 to its lowest level of 8% in 2006. It changed little, at 8.5% in 2007. The inverse relationship between spatial coverage of the fishery and commercial CPUE is likely a function of fisher searching behavior. It is likely that some fishers will search for new or alternate fishing grounds when catch rates are low or in decline in traditional areas. Conversely, when catch rates are high, there would be little need to search for alternate fishing grounds.

The fishery generally occurred progressively earlier from 2003 to 2006 (Fig. 19), with total effort expenditure decreasing over this time period. However, in 2007, the fishery was 3-4 weeks later starting (week 9) than in the previous two years. This was a result of unfavorable ice conditions in the spring of 2007 off southern Labrador. Despite this, the fishery was completed relatively early, by week 21, and the total recorded effort expenditure was at its lowest level in the time series, about 200,000 trap hauls.

Trends in commercial logbook CPUE throughout the season (Fig. 20) indicated that initial CPUE decreased during 2002-04 but increased from 2004 to 2007. The late-season CPUE in 2007 was higher than in the previous five years according to weekly trends (Fig. 20a) as well as trends in relation to cumulative catch (Fig. 20b). Trends in VMS CPUE throughout the season (Fig. 21) agreed with commercial CPUE, that initial and seasonal CPUEs were higher in 2007 than in the previous three years according to both weekly trends (Fig. 21a) and trends in relation to cumulative catch (Fig. 21b). The greater increase in VMS than logbook CPUE in 2007 described earlier (Fig. 17) was due to divergence of the 2006 and 2007 VMS trends as the season progressed (Fig. 21b) that was not evident in the logbook CPUE seasonal trends (Fig. 21a). This divergence in VMS CPUE between years included a substantial late-season increase in 2007.

Size distributions from at-sea sampling by observers (Fig. 22) show decreasing catch rates of legal-sized males from 1999 to 2004, reflecting the trend in CPUE (Fig. 14). Modal CW decreased from about 110-113 mm in 2002 to about 92-95 mm in 2004 reflecting depletion of legal-sized males and suggesting an increase in pre-recruits. Modal CW then increased to

101 mm in 2005, with an overall increase in abundance of legal-sized animals in the past two years, suggesting increase in the exploitable biomass.

The increase in observer catch rate of legal-sized males in 2006 was due to an increase in catch rate of old-shelled crabs (Fig. 22-23a). Further increase in catch rate in 2007 was due to a sharp increase in crabs classified as new-hard-shelled, while the catch rate of old-shelled crabs decreased sharply (Fig. 22-23a). This suggests some inconsistency in shell condition classification because an increase in abundance of old-shelled crabs should be preceded by an increase in new-hard-shelled crabs. Shell condition classification is highly subjective and the 3-stage scale used by observers (since 2000) is one that includes the intermediate-shell stage (of the 4-stage scale used during surveys) with the old-shell stage. When the new-hard and old shelled categories from at-sea sampling are pooled (Fig. 23b), their combined catch rate agrees well with observed CPUE during 2003-07. It is unclear to what extent this reflects misclassification of some new-hard-shelled crabs (shell 2) as old-shelled (shell 3) crabs versus retention of some new-hard-shelled crabs by the fishery.

The fall survey exploitable biomass index (Table 3, Fig. 24) has increased over the past five years but remains below levels observed prior to 2002. It had previously decreased steadily, by 94%, from 1998 to 2002.

The increase in the fall survey exploitable biomass index since (Fig. 24) was small relative to the increase in CPUE indices (Fig. 16). This reflects effects of recent changes in the fishery on fishery performance (CPUE) as described earlier.

Production

Recruitment: Recruitment has increased recently, as reflected by the increase in the exploitable biomass (Fig. 24) while landings increased (Fig. 13). We examined annual changes in biomass indices of legal-sized males from fall multi-species surveys, by shell condition (Fig. 25), toward evaluating the internal consistency of the data series. Males enter the legal-size group as soft-shelled crabs, after the spring molt, and they begin to contribute to the legal intermediate-shelled group in the following year. Trends in the biomass index by shell condition reflect this process, in that the biomass of new-hard-shelled males peaked in 1998 whereas that of intermediate-shelled males peaked one year later, in 1999. The biomass index of new-hard-shelled males dropped sharply in 1999, whereas biomass of intermediate-shelled crabs declined steadily during 1999-2002. The biomass of new-hard-shelled crabs has increased steadily from 2002 to 2006 while the biomass of older-shelled crabs has remained low. This suggests that the fishery has been highly dependent upon immediate recruitment.

The size compositions from fall multi-species surveys (Fig. 26) are examined with the abundance index (ordinate) truncated for smallest males (<50 mm CW), so as to focus on trends in abundance for larger males. 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. An increase in the pre-recruit index in 2004 (Dawe et al. 2005) 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 2005-07. The size distributions 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 during 2005-07 may have been derived from the large modal group of smallest males (<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 uncertain. However declining abundance of smallest males during 2003-06 (Fig. 26) together with the persistence of a warm oceanographic regime (Fig. 24) may suggest relatively poor recruitment prospects in the long term.

The catch rates of under-sized crab from at-sea sampling (Fig. 27) closely matched the catch rates of total discards for the second consecutive year in 2007, implying that most crabs discarded in the fishery were released because they were under-sized rather than soft-shelled. The catch rate of under-sized crabs has increased since 2005, to about the 2003-04 level in 2007.

The fall survey pre-recruit index (Table 4, Fig. 28) decreased from 1998 to a lower level during 1999-2003 before increasing sharply to a peak in 2004. It then decreased in 2005, was unchanged in 2006 and decreased further in 2007. Therefore, recruitment is expected to decrease in the next several years.

Reproduction: The percentage of mature females carrying full clutches of viable eggs (Fig. 29) has varied over the time series. It 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 subsequently decreased to 59% in 2006. The index increased to 72% in 2007. It is unknown to what extent changes in fecundity affect subsequent abundance of settling megalopae.

Mortality

Exploitation: The exploitation rate index (Fig. 30) increased sharply from 2000 to 2003, decreased sharply from 2003 to 2005, and has changed little since. Fishery and trawl survey data suggest that the exploitable biomass remains highly dependent upon immediate recruitment. Maintaining the current level of fishery removals would not likely result in any increase in the exploitation rate in 2008. However, an increase in fishery removals would likely accelerate an expected decline in the exploitable biomass in the near future.

Indirect fishing mortality: Fishery-induced mortality, on the pre-recruit as well as the exploitable populations, has decreased since 2003. The pre-recruit fishing mortality index (Fig. 30) increased sharply from 2001 to 2003, decreased sharply from 2003 to 2005, and has changed little since to remain at a very low level in 2007. The percentage of the total catch discarded (Fig. 30) increased sharply in 2002, was unchanged in 2003, and further increased to a record high level in 2004. It declined sharply over the next two years to the pre-2002 level, and changed little in 2007, implying reduced wastage of under-sized and new-shelled pre-recruits in the fishery in recent years. The sharp decline since 2004 is related to earlier fishing seasons that result in reduced catches of new-shelled immediate pre-recruits.

Although wastage of pre-recruits (percent discarded) was high in the 2002-05 fisheries (Fig. 30), 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 increased proportion of large, older-shelled crabs in the population due to increased recruitment during 2005-07.

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 (Miller 1977, Dufour et al. 1997).

Overall, observed weekly levels of soft-shelled crab (Fig. 31) were much lower in 2006 and 2007 than during 2002-05, consistent with the trend in overall percent discarded (Fig. 30). Peaks in percentage of soft-shell occurred progressively earlier each year from 2002 to 2005 (Fig. 31). 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 week-specific percentage of soft-shelled crabs in 2007 was, excepting week 11, as low or lower than it was in any of the previous five years and it, uniquely, never approached the 20% level (Fig. 31). The low levels of the past two years were likely due, in part, to increased abundance of large older-shelled crabs (Fig. 22) and resultant decreased catchability of soft-shelled immediate pre-recruits. Regardless of the cause, this implies little wastage of soft-shelled crabs in the 2006 and 2007 fisheries relative to earlier years.

The fishery had been occurring progressively earlier from 2003 to 2006 (Fig. 32), but was delayed in 2007 due to spring ice conditions. The bulk of the 2006 effort occurred from weeks 6-10 whereas most of the 2007 effort occurred from weeks 10-14, with 81% of the total trap hauls in that period . Soft-shelled crab catch rates remained at low levels in all weeks in 2007, and for the first time in the time series, did not exceed 20% at any point in the season. The weekly distribution of observed sets has better reflected that of total fishing effort in the past three years than it did in 2003 and 2004. In 2007, 59% of the observed sets occurred from weeks 10-14. There is increased confidence that weekly observations of soft-shelled crab reflect true prevalence in the fishery when the temporal distribution of observed sets agrees well with that of total fishing effort, as has been the case in recent years.

An area of Hawke Channel (Fig. 15) has been closed to all fisheries except snow crab from 2003 to 2007. The CPUE trended similarly inside and outside the closed area from 2003 to 2006 (Fig. 33). However, in 2007, CPUE increased inside the closed area while it decreased outside. It is unclear and pre-mature to infer whether or not this difference in 2007 may be attributable to the exclusion of other fisheries from this area.

Natural Mortality; (BCD): BCD occurs almost exclusively in recently-molted crabs (Dawe 2002). BCD in Div. 2J males (Fig. 34) has been most prevalent in small new-shelled adolescents of 40-59 mm CW. 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 has been virtually absent in all males during the past two years.

DIVISION 3K

The Fishery

Offshore landings (Table 5, Fig. 35) have generally been higher than inshore landings by a factor of 3-5. Offshore landings peaked in 1999 at 17,900 t. They decreased to about 13,000 t in 2000-04, due to reduction in TAC. Landings decreased sharply in 2005 when the TAC was not fully subscribed because the fishery was closed prematurely due to high levels of soft-shelled crabs in the catch (Dawe et al. 2006). Landings then increased by 55% to 9,450 t in 2007. Effort increased sharply in 2004, decreased sharply in 2005, and further declined by 28% to 2007.

Inshore landings (Table 5, Fig. 35) peaked in 1999 at 3460 t and decreased sharply in 2000 due to TAC reduction. They increased to 3340 t in 2003 and changed little in 2004. Landings decreased by 21% in 2005 and then increased by 9% to 2,820 t in 2007 while effort declined by 47%.

Commercial CPUE (Table 5, Fig 36) indicates that fishery performance has improved substantially in both inshore and offshore areas since 2005. Inshore CPUE has been consistently lower than offshore CPUE. Spatially, increases in CPUE occurred throughout the Division in 2007 (Fig. 37). The areas fished changed little from 1999 to 2003 (Dawe et al. 2004), and remained similar in 2004. In the inshore, there has been no clear change in spatial distribution of fishing effort in recent years, but in the offshore, there has been a decline in effort in the St. Anthony Basin (extreme north portion of the Division) since 2004.

Effect of ocean climate variability

Bottom temperature in Div. 3K, has been inversely related to the divisional (inshore and offshore) commercial CPUE, at an eight year lag, since the early 1980's (Fig. 38). However, since 2005 CPUE has increased to a very high level while bottom temperature has remained high. This substantial improvement in fishery performance is likely due in part to the reduction in fishery removals since 2004 (Fig. 35). However it likely also reflects increased biomass which may be due to a general trend toward earlier fishing seasons since 2003, and reduced fishing effort since 2004 (Fig. 35) which resulted in reduced fishing mortality on soft-shelled pre-recruits.

DIVISION 3K OFFSHORE

Biomass

The commercial logbook, observer, and VMS CPUE indices have all increased sharply since 2005 (Fig. 39). Commercial CPUE increased sharply from 2005 to 2007 to approach the highest level previously observed (in 1993, Table 5), following a decline to its lowest level in 2005. In 2007, the observer CPUE was at its highest level since 1995-96 while the VMS CPUE was at its highest level in the four year time series, at about 500 kg/hr.

The spatial coverage of the fishery has been inversely related to commercial CPUE since 1995 (Fig. 40). The percentage of available 5' x 5' cells occupied by the fishery declined from its highest level of 48% in 2004 to its lowest level since 1995 in 2007.

The fishery generally occurred progressively earlier from 2003 to 2006 (Fig. 41), with total effort expenditure decreasing since 2004. However, in 2007, the fishery was delayed with minimal effort occurring up until week 6, by which time the majority of the 2006 fishery had occurred. This delay is attributable to unfavorable ice conditions in the spring of 2007 off the northeast coast of Newfoundland. Despite this, the fishery progressed fairly rapidly, with the most of the approximately 550,000 trap hauls completed by week 11.

Trends in commercial logbook CPUE throughout the season (Fig. 42) indicate that initial CPUE has increased in 2006-07, above the 2002-05 levels. The mid to late-season CPUE in 2007 was higher than in the previous three years according to weekly trends (Fig. 42a) and higher than in the previous five years according to trends in relation to cumulative catch (Fig. 42b). Trends in VMS CPUE throughout the season (Fig. 43) agreed with logbook CPUE, indicating that CPUE was at its highest level in the 4-year time series throughout the 2007 fishing season according to both weekly trends (Fig. 43a) and trends in relation to cumulative catch (Fig. 43b).

Size distributions from at-sea sampling by observers (Fig. 44) indicate that modal CW increased from 101 mm in 2001 to 110 mm in 2002, and has since remained at that size. There has been an overall increase in catch rate of most sizes of legal-sized older-shelled animals in the past two years. In 2003, new-hard-shelled crab represented the highest proportion of legal-sized crabs sampled by observers (Fig. 45a), but the level decreased in 2004 and has since been unchanged. Catch rates of legal-sized old-shelled crab have increased since 2004 to their highest level in 2007 (Fig. 45a). Observed catch rates of soft-shelled crab were at their lowest level in the time series in 2006-07, constituting a minimal portion of the catch. Trends in the catch rate of new-hard and old-shelled legal-sized crab, when combined, have agreed well with observed CPUE since 2004 (Fig. 45b). As we noted for Div. 2J, it is unclear to what extent this reflects misclassification of some new-hard-shelled crabs (shell 2) as old-shelled (shell 3) crabs versus retention of some new-hard-shelled crabs by the fishery.

The exploitable biomass has increased substantially over the past two years. The fall survey exploitable biomass index (Table 6, Fig. 46) has increased steadily since 2003 to its highest level since 1998. It had previously decreased from its highest level by almost half in 1999 and changed little until it decreased again from 2001 to its lowest level in 2003.

The industry-DFO collaborative post-season offshore trap survey catch rates of legal-sized crabs, from stations common to all years, varied without trend from 2004 to 2007 (Fig. 47). This limited time series of trap survey data did not reflect the recent steady increase in the exploitable biomass index from the post-season trawl survey (Fig. 46).

Production

Recruitment: Recruitment has increased in recent years, as reflected by the substantial increase in exploitable biomass (Fig. 46) while landings increased (Fig. 35). Annual changes in the exploitable biomass index by shell condition (Fig. 48a) do not show a consistent trend of peaks in new-shelled biomass preceding peaks in intermediate-shelled biomass, as was evident in Div 2J. This may be due to annual differences in catchability of crabs by the survey trawl (Dawe et al. 2002a). Recently however, an increase in biomass of new-hard-shelled crabs since 1994 was followed by an increase in biomass of intermediate-shelled crabs since 2005 (Fig. 48) Increase in the exploitable biomass since 2005 was reflected by an increase in the percentage of intermediate-shelled crab (Fig. 48b).

Trends in legal-sized crab by shell condition from the industry-DFO collaborative trap survey (commercial mesh size, Fig. 47) varied without trend from 2004 to 2007. Size distributions during this survey (Fig. 49) showed an increase in modal size from about 95 mm CW in 2004 to about 110 mm in 2006, coincident with an increase in catch rates of new-shelled legal-sized crab in 2006. This suggests increased recruitment since 2004, consistent with fall the multi-species trawl survey trend.

A group of small adolescents has been apparent in the fall trawl survey size distributions (Fig. 50) during the past two years that achieved a modal size of about 65 mm CW in 2007. These adolescents are expected to begin to recruit to the exploitable biomass in about three years. Longer-term recruitment prospects are uncertain. However decreased abundance of smallest males (<50 mm CW) in the 2007 fall trawl survey (Fig. 50) together with the persistence of a warm oceanographic regime (Fig. 38) may suggest relatively poor recruitment prospects in the long term.

The observed catch rates of under-sized crabs closely matched the catch rates of total discards for the second consecutive year in 2007 (Fig. 51), implying that most of the discarded catch was comprised of under-sized crabs. This contrasts 2004 and 2005 when catch rates were much higher for total discards than for under-sized crabs, which implied high prevalence of soft-shelled crabs. Catch rates of undersized crabs have been unchanged since 2002.

The fall survey pre-recruit index (Table 7, Fig. 52) declined from 1997 to a lower level during 1999-2002. It then increased to peak in 2006 and decreased sharply in 2007. Recruitment remains promising for the next several years although it may decrease slightly in the next 1-2 years.

Reproduction: The percentage of mature females carrying full clutches of viable eggs (Fig. 53) varied at a high level from 1995 to 2004, exceeding 80% in all years but 1996. It fell to 61% in 2005 and 74% in 2006, but returned to a high level of 90% in 2007.

Mortality

Exploitation: The exploitation rate index (Fig. 54) has changed little in the past three years at about the long-term average. The high mortality indices for 2004 are likely due to anomalously low biomass indices from the 2003 survey (Fig. 46 and 50). The catch rate of old-shelled crabs increased sharply in 2007, indicating that the exploitable biomass has become less dependent upon immediate recruitment. Fishery removals could likely be increased in 2008 without increasing the exploitation rate.

Indirect fishing mortality: The pre-recruit fishing mortality index (Fig. 54) decreased sharply in 2006 and was at its lowest level in 2007. The percentage of the total catch discarded in the fishery (Fig. 54) 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 pre-recruits in the catch, which resulted in a premature closure of the fishery and failure to achieve the TAC (Fig. 35, Dawe et al. 2008). The percentage discarded decreased sharply in 2006 to its lowest level and was unchanged in 2007. This implies greatly reduced wastage of pre-recruits in the fishery during 2006 and 2007.

Overall, observed weekly levels of soft-shelled crab were relatively low in 2006 and 2007 (Fig. 55). Peaks in percentage of soft-shell occurred progressively earlier from 2003 to 2005. This trend may be related to annual changes in time of molting and abundance of pre-recruits. However it is more likely 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 low weekly percentages of soft-shell crabs in 2006-07, are likely due, in part, to increased abundance of large older-shelled crabs (Fig. 44) and resultant decreased catchability of soft-shelled immediate pre-recruits. Regardless of the cause, this implies a decrease in wastage of soft-shelled crabs in the 2006 and 2007 fisheries compared to the high levels of the preceding years.

The fishery occurred earlier each year from 2003 to 2006 (Fig. 56), but was delayed in 2007 due to spring ice conditions off northeast Newfoundland. The bulk of the 2006 effort occurred from weeks 3-6 whereas most of the 2007 effort occurred from weeks 5-11, with 90% of the total trap hauls in that period . Soft-shelled crab catch rates remained at low levels in all weeks in 2007, and for the second consecutive year did not exceed 20% at any point in the season. The weekly distribution of observed sets has agreed well with that of total fishing effort in the past four years than it did in 2003 (Fig. 56). In 2007, 85% of the observed sets occurred from weeks 5-11. There is increased confidence that weekly observations of soft-shelled crab reflect true prevalence in the fishery when the temporal distribution of observed sets reflects that of total fishing effort, as was the case in the Div. 3K offshore fishery during the past four years.

The Funk Island Deep in the southern part of offshore Div. 3K (Fig. 37) was closed to gillnet fisheries in 2002 and has been closed to all fisheries except snow crab during 2005-07 (Fig. 57). It would be premature to draw any conclusions regarding the impact of this closure on the snow crab resource but CPUE has increased both inside and outside of the closed area since 2005. While CPUE was much higher inside than outside the closed area in 2007, this was also commonly the case prior to 2001 when no closure was in place.

Natural Mortality (BCD): Prevalence of BCD, from multi-species trawl samples (Fig. 58), 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. Annual trends in BCD prevalence (across all sizes) were similar to those in the survey biomass indices, especially for pre-recruits (Fig. 52), featuring highest values in 1996-98, a sharp drop to minimum levels in 1999, and generally lower levels during 2000-07 than during 1996-98. This implies a possible density-dependent effect on prevalence. The very low prevalence levels, across all sizes for both adolescents and adults in 1999 and 2003 (Fig. 58) coincides with anomalously low survey biomass indices, especially for pre-recruits (Fig. 52). If those anomalously low biomass indices are due to low trawl efficiency, as believed, then this implies that infected crabs have a higher catchability by the survey trawl than healthy crabs. Prevalence levels in 2007 were comparable to those in 2006 for most sizes of crab, with a slight increase in largest (>94 mm CW) adolescents.

DIVISION 3K INSHORE

Biomass

CPUE increased sharply from 2005 to 2007 to approach the highest level previously observed (Table 5, Fig. 36), following a decline during 2002-05. The observer CPUE index agreed with logbook CPUE, increasing sharply in 2007 (Fig. 59). The observer CPUE has varied without trend since 1999. This could be attributable to spatial and temporal variability in annual observer coverage and low levels of coverage in this area.

The spatial coverage of the fishery has been inversely related to commercial CPUE since 1998 (Fig. 60). The percentage of available 5' x 5' cells occupied by the fishery declined from its highest level of 44% in 2004 to 30% in 2006 and was unchanged in 2007.

The fishery, as in the offshore, occurred progressively earlier each year from 2003 to 2006 (Fig. 61), but was delayed in 2007 due to severe spring ice conditions. Total effort expenditure has been decreasing since 2004. There was little effort expended in the delayed 2007 fishery until week 9, the point at which about two-thirds of the 2006 fishery had occurred. Despite this, the fishery progressed rapidly in the following four weeks, and was virtually finished by week 13, earlier than during 2003-05.

Trends in commercial CPUE throughout the season (Fig. 62) indicated that early-season 2007 CPUE was similar to that during the previous 5 years, excepting 2005. The mid to late-season weekly CPUEs in 2007 were at a comparable level to those of 2002, higher than in the previous four years (Fig. 62a). Trends in relation to cumulative catch (Fig. 62b), showed that at comparable catch levels throughout the season 2007 CPUE was the highest in the time series.

Size distributions from at-sea sampling by observers (Fig. 63) indicate that modal CW decreased from 95 mm in 2001 to below legal-size, at 89 mm, in 2003. Modal CW then increased to 101 mm CW in 2005 while catch rates of legal-sized soft and new-hard-shelled crabs increased (Fig. 64), indicating increasing abundance of immediate pre-recruits. Modal CW further increased to 110 mm in 2006-07, as catch rate of old-shelled crabs increased (Fig. 64), indicating increasing recruitment The observed catch rates of legal-sized soft and new-hard-shelled crab decreased from 2005 to 2007 (Fig. 64a), while the catch rates of old-shelled crab increased to their highest levels. The CPUE of all crabs kept exceeded that of old-shelled crabs to a much greater degree inshore (Fig. 64a) than was the case offshore (Fig. 45a). The extent to which this reflects a higher level of mis-classification of intermediate-shelled crabs as new-hard shelled versus a higher proportion of new-hard-shelled crabs in the retained catch, in inshore Div. 3K, is unknown. The catch rate of new-hard and old-shelled legal-sized crab, when combined, has exceeded the retained (kept) catch since 2004 (Fig. 64b). Variability in this relationship in the earlier period of 1999-2003 is likely attributable to lower levels of observer coverage and spatial or temporal variation in sampling across years by observers in the inshore areas of Div. 3K.

The exploitable biomass has recently increased. Collaborative post-season trap surveys show that catch rates of legal-sized crabs increased slightly from 2004 to 2006 and were unchanged in 2007 (Fig. 65). Those surveys also showed that catch rates of older-shelled legal-sized crabs have increased since 2004.

Production

Recruitment: Recruitment has increased in recent years, as reflected by increases in CPUE (Fig. 59) and in trap survey catch rates of legal-sized crabs (Fig. 65). Trends in abundance of new-shelled legal-sized crabs from the industry-DFO collaborative survey (Fig. 65) have remained higher than for older-shelled legal-sized crabs from 2004 to 2007. Trap size distributions by shell condition from this survey (Fig. 66) have changed little over the past four years with a primary mode increasing slightly from 90 to 94 mm CW during 2004-07.

Data from the DFO inshore post-season trap survey (Fig. 67) indicate a high level of spatial variability in catch rates from both small-meshed (Fig. 68a) and large-meshed (Fig. 68b) traps. Recent catch rates of new-shelled (soft + new-hard) legal-sized males (immediate pre-recruits) generally peaked in 2003 due to high catch rates of soft-shelled crabs in particular. In White Bay, new-shelled crab catch rates subsequently declined while catch rates of old-shelled (intermediate + old) crabs increased to 2005 in stratum 614 and to 2006 in deeper stratum 613. In Notre Dame Bay, catch rates of new-shelled crabs have generally changed little since 2003, except for anomalously low catch rates in 2004 that likely reflect reduced catchability by traps in that year. Catch rates of old-shelled crabs have increased steadily over the past 2-3 years in both Notre Dame Bay strata. In deeper stratum 610, the 2007 catch rate of new- and old-shelled crabs combined was the highest in the time series.

The catch rates of under-sized crabs in 2007 from at-sea sampling agreed with the catch rates of total discards for the first time since 2003 (Fig. 69), implying that most of discarded catch was comprised of under-sized crabs. The much greater catch rate of total discards than of under-sized crabs during 2004-06, and particularly during 2005, reflects a high incidence of soft-shelled crabs in the catch. Catch rates of under-sized crabs declined from 2003 to their lowest level in 2006, with little change in 2007.

Size frequencies from the inshore DFO trap surveys show much clearer trends in White Bay (Fig. 70) than in Notre Dame Bay (Fig. 71). White Bay distributions 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 group of small adolescent males has also been apparent in the White Bay during the past three years (Fig.70) that is not apparent in Notre Dame Bay (Fig. 71). This group first appeared in 2005 in shallow stratum 614 at a modal size of about 50 mm CW, then in 2006 in deeper stratum 614 at slightly larger size, and subsequently in 2007 in deepest stratum 613 at a modal size of about 62 mm CW. A large portion of this pulse appears to have terminally-molted to sub-legal-sized adult crab, especially in stratum 615. This group is expected to imminently begin to achieve legal size in stratum 613 and subsequently begin to recruit to the fishery.

In Notre Dame Bay (Fig. 71), 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. 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 reflecting changes in trap catchability, as noted earlier. A very high proportion of males in stratum 611 terminally molt at small sizes (Fig. 71), perhaps to a greater extent than in shallow White Bay stratum 615 (Fig. 70). Inability to detect trends in Notre Dame Bay may be due to strong annual variability in such variables as molting probability, probability of terminally molting and trap catchability.

Recruitment remains promising for the next several years although it may decrease slightly in the next 1-2 years. The group of sub-legal-sized adolescent crabs apparent in the DFO trap survey is expected to recruit to the exploitable biomass in 3-4 years, whereas collaborative trap survey catch rates show an increase in new-shelled legal-sized crabs in the past two years.

Mortality

Exploitation: Data are insufficient to estimate fishery-induced mortality indices because the fall trawl survey is not consistently conducted in inshore areas and so an exploitable biomass index is not calculated. However it has been concluded that the exploitable biomass has recently increased based on trends in CPUE in relation to landings and trap survey catch rates. Therefore, maintaining the current level of fishery removals would not likely result in an increase in the exploitation rate.

Indirect fishing mortality: The percentage of the total catch discarded in the fishery (Fig. 72) increased from 2002 to about 40% in 2004-05, reflecting increased wastage of under-sized and new-shelled pre-recruits. The high wastage in 2004-05 is consistent with a high incidence of soft-shelled pre-recruits in the catch. In 2005, this resulted in a premature closure of the fishery and failure to achieve the TAC (Dawe et al. 2008). The percentage of the catch discarded declined sharply in 2006 and 2007 to its lowest level implying a low level of wastage in the fishery in 2007.

Overall, observed weekly levels of soft-shelled crab (Fig. 73) were lower in 2007 than in 2004-06. The percentage of soft-shell in the catch increased as the season progressed and approached 20% in week 15, but peak incidence occurred later than in the 2004-06 seasons. The low level in 2007, despite a delayed season opening (Fig. 61) was likely due to an increased abundance of large older-shelled crabs (Fig. 63) and resultant decreased catchability of soft-shelled immediate pre-recruits. Regardless of the cause, this implies a decrease in wastage of soft-shelled crabs in the 2007 fishery.

The fishery occurred earlier each year from 2003 to 2006, but was delayed in 2007 (Fig. 74) due to spring ice conditions off northeast Newfoundland. Most of the 2006 effort was expended from weeks 4-10 whereas most of the 2007 effort occurred from weeks 9-13, with 85% of the total trap hauls in that period. Soft-shell crab catch rates remained at relatively low levels in all weeks in 2007 but began to approach 20% near the latter parts of the season. The weekly distribution of observed sets agreed better with that of total fishing effort in 2005 and 2007 than it did in 2006, or in 2003-04 (Fig. 74). Therefore the decrease in percent soft-shelled crab from 2005 to 2007, based on observer data, likely reflects reality.

Natural Mortality (BCD): Prevalence of BCD, from inshore post-season trap surveys has been periodic (Fig. 75). BCD was initially detected in the post-season trap survey in 1995, increased sharply in 1996 and peaked at 9% in 1998. Prevalence decreased steadily in 1999 and 2000 (no survey in 2001) to a low of 1% in 2002. Prevalence once again increased sharply from 2002 to 2006, with a second peak of 13% in 2006. Overall prevalence remained high, but decreased slightly in 2007. Peaks in prevalence in Notre Dame Bay have preceded peaks in prevalence in White Bay by 1-2 years (Fig. 75). Similarly, peaks in prevalence in the shallowest stratum of White Bay have preceded peaks at successively deeper strata by 1-2 years, similar to the trend observed in catch rate of small adolescents (Fig. 70). In contrast, spatial or temporal lag effects have not been apparent between depth strata in Notre Dame Bay (Fig. 75). These spatial and temporal lags in prevalence between bays and depth strata could be attributable to annual changes in abundance (density dependence), migration, or circulation effects which may influence distribution of the parasite.

BCD has consistently occurred at much higher prevalence levels in these inshore Div. 3K trap survey samples (Fig. 76-77) than in the predominately offshore Div. 3K Campelen trawl samples (Fig. 58). This likely reflects differences in catchability of diseased animals between traps and trawls (based on comparative trap/trawl sampling), but it may also, in part reflect higher prevalence in inshore than offshore areas. Prevalence of infection has also been higher in adolescent than adult crabs in all trap survey strata (Fig. 76-77), a phenomenon that was not evident in the offshore trawl survey data (Fig. 58), suggesting that traps may select for diseased adolescents. In all strata of White Bay and Notre Dame Bay, except stratum 610, BCD prevalence tended to increase with crab size in adolescents and decrease with increasing size in adults. 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.

In White Bay during 1995-99 there was a clear progression of BCD to successively larger crabs and successively greater depths (Fig. 76), 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 (Fig. 76) increased in 2004 in small new-shelled males within the shallowest stratum and subsequently increased in progressively larger crabs in this stratum (Fig. 76). Prevalence levels have remained similar in all sizes of adolescents during 2005-2007 in this stratum but have decreased for most sizes of adult crabs since 2004. BCD prevalence also increased greatly in all sizes of adolescent males in the intermediate-depth White Bay stratum in 2005 and remained high during 2006-07, with about 70% of the largest new-shelled adolescents infected in 2007. BCD prevalence increased sharply in the deepest stratum in small males, in 2007.

In Notre Dame Bay (Fig. 77) prevalence (especially in adolescents) in the shallower stratum shifted from being highest in smallest males (40-75 mm CW) in 1995 to being highest in largest (legal-sized) males in 1998 and 1999. This trend was later repeated with prevalence shifting from being highest in smallest males in 2003 to being highest in largest males in 1998 and 1999. Such trends were less clear in the deeper stratum, but there appeared to be some progression of prevalence in adolescents to larger sizes during 1996-97 and during 2002-04.

DIVISION 3L

The Fishery

Offshore landings (Table 8, Fig. 78) have generally been higher than inshore landings by a factor of 3 in recent years. Offshore landings peaked at 20,800 t in 1999 and decreased to 17,900 t in 2000 and 2001 due to a reduction in TAC. Landings have increased since 2001 and reached their highest level in 2007 at 21,000 t – a 17% increase since 2001. Effort increased steadily since 2000 to its highest level in 2007.

Inshore landings (Table 8, Fig. 78) peaked in 1996 at 7,900 t. They declined to 4,700 t in 2000, increased to 6,800 t in 2003, and decreased slightly to 6,400 t in 2004 due to changes in TAC. Landings changed little between 2004 and 2007 (6490 t), while effort declined by 27%.

Commercial CPUE (Fig. 79) indicates that fishery performance has deteriorated offshore but improved inshore over recent years. Inshore CPUE has historically been lower than offshore CPUE, but there was little difference in 2007. There has been little change in the spatial distribution of fishing effort in recent years (Fig. 80).

Effect of ocean climate variation

Bottom temperature in Div. 3L, has been inversely related to the divisional commercial CPUE at an eight year lag since the early 1970’s (Fig. 81). Divisional CPUE has changed little, at a relatively low level while the lagged bottom temperature has remained high. The recent stabilization of the divisional CPUE is due to improvement in the inshore fishery, while offshore fishery performance has continued to deteriorate (Fig. 81).

DIVISION 3L OFFSHORE

Biomass

The commercial logbook and observer CPUE indices (Fig. 82) have both decreased steadily from 2002 to 2007, to their lowest levels since 1991 (Fig. 79). VMS-based CPUE (Fig. 82) decreased from 2004 to 2006 and was unchanged in 2007.

The spatial coverage of the fishery has generally been inversely related to commercial CPUE (Fig. 83). The percentage of available 5’ x 5’ cells occupied by the fishery has remained at its highest level of 31-32% since 2004, while CPUE has been declining. Annual changes in the extent of spatial coverage of the Div. 3L offshore fishery are less abrupt than in other divisions.

The Div. 3L offshore fishery primarily occurs along the broad slope of the northern portion of the Grand Bank (Fig. 80), whereas in other divisions effort more commonly occurs at greater depths. Bathymetric and habitat (e.g. muddy substrate) limitations in offshore Div. 3L may account for the limited annual variation in fishing effort distribution.

The timing of the 2007 season was similar to that in 2006 (Fig. 84), beginning earlier than those of the previous three years, especially 2005. The 2007 fishery started in the first week of April and lasted 19 weeks, finishing slightly earlier than in the previous years, except for 2005. The level of recorded effort has steadily increased, from about 1,150,000 trap hauls in 2003 to about 1,600,000 trap hauls in 2007.

Trends in commercial logbook CPUE throughout the season (Fig. 85) indicate that initial CPUE in 2007 was comparable to that of 2005 and 2006 and lower than it was during 2002-04. CPUE was generally lower throughout the season in 2007 than it was during the previous 5 years, especially until week 9 (Fig. 85a) up to a cumulative catch of about 10,000 t (Fig. 85b). Seasonal VMS-based CPUE trends throughout the season since 2004 (Fig. 86) similarly showed lowest CPUE in 2007 during the first part of the season but comparable or higher CPUE during the remainder of the season in 2007 relative to 2004-06.

Size distributions from at-sea sampling by observers (Fig. 87) became increasingly platykurtic over the past 8 years. Modal CW increased from 104 mm in 2001 to 110 mm in 2005-06 as catch rates of most size groups decreased, suggesting low levels of recruitment into the fishery. Playtkurtosis further increased in 2007 due to a slight increase in catch rates of small (about 86-104 mm) new-shelled males. Observed catch rates of new-shelled legal-sized crabs have declined from 2001 to 2005 whereas catch rates of legal-sized old-shelled crabs have declined since 2002 (Fig. 88a). Catch rates of both categories have changed little in the past three years indicating persistent low recruitment. Catch rates of old-shelled crabs have consistently been higher than those of new hard-shelled crabs, and catch rates of soft-shelled crabs have been consistently low (Fig. 88). Trends in the levels of new-shelled and old-shelled legal-sized crab, when combined (exploitable crabs), have reflected the observed CPUE throughout the time series, better than in Div. 2J (Fig. 22) or Div. 3K offshore (Fig 45). This agreement, in offshore Div. 3L has been particularly tight since 2004 (Fig. 88b), as we also noted for offshore Div. 3K (Fig. 45b).

The exploitable biomass has declined in recent years. The fall survey exploitable biomass index (Table 9, Fig. 89) declined from 1996 to 2000 and remained at that lower level until it further decreased to its lowest level in 2006. It increased from 2006 to 2007 but remained low relative to previous years. The collaborative trap survey catch rates of legal-sized crabs (from common stations) also declined from 2004 to 2007 (Fig. 90).

Production

Recruitment: Recruitment has remained relatively low in recent years, as reflected by the decline in exploitable biomass (Fig. 89) while landings increased slightly (Fig. 78). Annual changes in the fall multi-species trawl survey biomass index by shell condition (Fig. 91a) reflected greater internal consistency than was evident in Div. 3K. Biomass of new-shelled legal-sized males declined from 1996-1999, whereas intermediate-shelled legal-sized males declined later, from 1998 to 2000, and old-shelled crabs declined later again, from 1999 to 2001. Biomass of all shell categories generally declined subsequently to record low levels in 2006. The biomass index of new-shelled legal-sized crabs has remained low following the decline during 1996-99 (Fig. 91a) .Biomass of new-shelled legal-sized crabs increased slightly in 2007 while biomass of all other categories remained very low. The increase in percentage of the survey legal-sized catch that was new-shelled (Fig. 91b) implies an increased dependence of the exploitable biomass on recruitment.

Catch rates of old-shelled legal-sized crabs by shell condition from the collaborative post-season trap survey common stations (Fig. 90) declined sharply by about half from 2005-07, reflecting persistent low recruitment in recent years. Meanwhile, catch rates of new-shelled crabs have varied without trend, at a lower level than that of old-shelled crabs. Size distributions showed a substantial decrease in catch rates of legal-sized new-shelled crab in 2004 with little change thereafter (Fig. 92). Catch rates decreased across the entire size range in 2006, and further decreased for largest crabs (>100 mm CW) in 2007. Meanwhile, catch rates of small crabs (about 86-100 mm CW) increased in 2007 due to an increase in soft-shelled crabs in particular.

Size distributions from the fall multi-species trawl survey show the presence of a group of small adolescents in recent years that achieved a modal size of about 80 mm CW in 2007 (Fig. 93). These adolescents are expected to begin to recruit to the exploitable biomass in the immediate future.

The observed catch rate of under-sized crabs agreed with that of total discards in 2007 (Fig. 94), implying that discards consisted virtually entirely of undersized crabs. Undersized crabs have apparently represented most of the discards since 2004. This contrasts earlier years, especially 2001 (Fig. 94) when undersized crabs did not represent most of the discards, implying that soft-shelled crabs represented a more important component of the discards than they have in recent years.

Recruitment is expected to increase over the next several years. The fall trawl survey pre-recruit index (Table 10, Fig. 95) increased in 2007 to its highest level since 1998.

Reproduction: The percentage of mature females carrying full clutches of viable eggs (Fig. 96) declined from 100% in 1995 to about 50% in 2001. Since 2002, the level has varied between 80-97%, with about 90% of females carrying full clutches in 2007.

Mortality

Exploitation: The exploitation rate index (Fig. 97) increased from 1996 to 2001 and changed little to 2006. The pre-recruit fishing mortality index (Fig. 97) increased gradually to 2001, doubled to 2003, and was lower in 2004 and 2006. Both indices increased to very high levels in 2007. These sharp increases in 2007 were due to decreases in the survey exploitable biomass index (Fig. 89) and pre-recruit biomass index (Fig. 95) in 2006. Increased removals, under the present scenario of reduced biomass and imminent recruitment increase, could result in increased mortality on soft-shelled immediate pre-recruits.

Indirect fishing mortality: The percentage of the total catch discarded in the fishery (Fig. 97) 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 prevalence of soft-shelled crab in the catch throughout the season (Fig. 98) was lower in offshore Div. 3L than it was in Div. 2J (Fig. 31) or offshore 3K (Fig. 55). The weekly percentage of soft-shelled crab in 2007 gradually increased as the season progressed but remained low throughout the fishing season as in previous years. Soft-shell crab comprised 0-2% of the weekly catch until week 15. It increased slightly in the latter parts of the season, reaching a maximum of about 15% in week 18, the last week of the fishery.

The fishery started earlier in 2006 and 2007 than in previous years (Fig. 99), as was also true for offshore Div. 3K (Fig. 56). However the offshore Div. 3L fishing season has remained much more prolonged, spanning 19 weeks in 2006 and 2007 (Fig. 99), 6-7 weeks longer than the offshore Div. 3K fishery , Despite the prolonged offshore Div. 3L fishing season, soft-shelled crab catch rates have remained at low levels in all weeks in all years.. The weekly distribution of observed sets has agreed well with that of total fishing effort since 2003 (Fig. 99). In 2007, 86% of the observed sets occurred from weeks 3-15. There is increased confidence that weekly observations of soft-shelled crab reflect true prevalence in the fishery when the distribution of observed sets agrees well with that of total fishing effort such as in Div. 3L offshore since 2003.

Natural Mortality (BCD): BCD generally occurs at lower levels in Div. 3L than in Div. 3K. Prevalence (in new-shelled males) from offshore Div. 3L fall multi-species trawl surveys (Fig. 100) has been variable with highest incidence during 2003-05. Prevalence of infection increased from 2000 to 2005, decreased considerably in 2006, and was non-existent in most groups of crabs in 2007. Maximum prevalence was about 8% in 40-59 mm CW adolescents and 14% in 60-75 mm CW adults during 2004.

DIVISION 3L INSHORE

Biomass

Logbook and observer CPUE indices (Fig. 101) trended together from 2002 to 2006. Both indices showed a decline in catch rates from 2002 to 2004, with a subsequent increase in 2006. However, the trends opposed one another in 2007 as logbook CPUE increased while observer CPUE decreased. The reasons for this disagreement are unclear. Regardless of the cause, 2007 represented the first year in the time series that the level of CPUE agreed between the two indices. From 1999 to 2006, observer CPUE was consistently higher than logbook CPUE, but in 2007 catch rates of both indices were equal, at about 12 kg/trap. The basis for the disparity between indices is unknown but it has generally decreased since 2001.

The spatial coverage of the fishery has generally been inversely related to commercial CPUE (Fig. 102). The percentage of available 5' x 5' cells occupied by the fishery was at a lower level before 2002 than it has been in more recent years. From 1995 to 2001, the level of occupied cells varied between 30-45% before increasing sharply to about 70% in 2002. The spatial coverage of the fishery has since varied about this higher level, with 60-80% of available cells occupied in any given year. The sharp increase in spatial coverage by the fishery in 2002 was followed one year later by a sharp decline in CPUE. CPUE has increased since 2004 while the area fished has generally decreased.

From 2003 to 2005, the fishery commenced in May (weeks 5-8 following April 1), and ended in week 24 (Fig. 103). However, in 2006 the fishery started in the second week of April, six weeks earlier than in 2005, and ended in week 20, a month earlier than in 2003-05. During this period, the total recorded effort expended in the fishery decreased gradually, from about 700,000 trap hauls in 2003-04 to about 575,000 trap hauls in 2006. In 2007, the fishery was delayed in opening relative to 2006 with minimal effort occurring up until the first week of May (week 5). This is attributable to unfavorable ice conditions in the spring of 2007 along the east coast of

Newfoundland. Despite this delay, the fishery progressed fairly rapidly with most of the effort expended by weeks 14-15, 1-2 months earlier than in previous seasons. There was a large decrease in total effort expended, with about 400,000 recorded trap hauls in 2007.

Trends in commercial CPUE throughout the season (Fig. 104) indicated that early and mid-season CPUE decreased from 2002 to 2004 but recovered from 2005 to 2007. In most years, there was a pattern of seasonal depletion, with an increase in CPUE in the mid-portions of the season, from weeks 7-13 (Fig. 104a). Only in 2005 was steady depletion evident throughout the season (Fig. 104b) The late-season CPUE at comparable removal level, in 2007 was at the second highest level in the time series, approaching the 2002 level (Fig. 104b).

Size distributions from at-sea sampling by observers (Fig. 105) changed very little between 2002 and 2005 with modes at 92 and 98-101 mm CW. The size distributions became platykurtic over the past two years due to declining catch rates of small (<107 mm CW) crabs.. The catch rates of legal-sized old-shelled crab have decreased since 2000 (Fig. 106a) while the catch rates of legal-sized new-shelled crab have varied at 5-8 kg/trap since 2002. Observed levels of soft-shelled crab have remained at a low level throughout the time series. With the exception of 2004, trends in the catch rates of intermediate and old-shelled legal-sized crab, when combined (exploitable crabs), have reflected the observed CPUE since 1999 (Fig. 106b). As in other areas, agreement between these indices has been particularly close in recent years, in this case 2005-07 (Fig 106b).

The exploitable biomass has recently increased. CPUE increased by 39% from 2004 to 2007 (Fig. 79) after decreasing from 2002 to 2004. Collaborative post-season trap survey catch rates of legal-sized crabs increased slightly from 2004 to 2006 and were unchanged in 2007 (Fig. 107).

Production

Recruitment: Recruitment has increased in recent years, as reflected by the increase in exploitable biomass while landings changed little (Fig. 78). However, collaborative survey catch rates of legal-sized new-shelled crabs show no trend since 2004 (Fig. 107). Size distributions by shell condition from this survey have changed little over the past five years (Fig. 108).

Data from small-mesh traps in inshore DFO trap surveys in Bonavista and Conception bays (Fig. 109) show increased catch rates of legal-sized new-shelled males from 2000 to 2005 in both areas (Fig. 110a). In summer, in Bonavista Bay, catch rates of new-shelled legal-sized males declined in 2006 and 2007 while catch rates of old-shelled legal-sized males increased. Intermediate and old-shelled crab represented the greatest proportions of catches from 1996 to 2000 but from 2001 to 2005 soft and new hard-shelled crabs were most common. The percentage of intermediate-shelled crabs in the catch increased in 2006 and 2007. In fall, in Conception Bay, 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. There was a slight decrease in 2007 associated with a sharp increase in catch rates of old-shelled legal-sized crab from the low level of 2003-06. The percentage of intermediate and old-shelled crab in the catch decreased from 1999 to 2006 but increased in 2007. Trends in catch rates and composition by shell condition from large-meshed traps (Fig. 110b) reflect those from the small-meshed traps in both bays.

The observed catch rate of under-sized crabs in inshore Div. 3L closely matched the catch rate of total discards in 2007 (Fig. 111), implying that the majority of discarded catch was comprised of under-sized crabs. This contrasts the previous two years when catch rates of under-sized crabs were lower than those of total discards, implying a higher proportion of soft-shelled crabs in the discards. Trends in these two indices have generally agreed since 2001. Catch rates of under-sized crabs declined sharply in 2002 and have since continued to decline, gradually to their lowest level in 2007.

Male size distributions from the DFO inshore trap surveys (Fig. 112) show considerable year-to-year changes in small-meshed trap catch rate across a broad size range for both adolescents and adults. For example there was a large increase in catch rate across a broad size range in Conception Bay in 2004, and, to a lesser extent, in Bonavista Bay in 2006. These increases were followed by decreases the following year, indicating changes in catchability by traps. Despite this effect, a group of pre-recruit adolescents has been evident in Conception Bay since 2004, maintaining recent recruitment, as reflected by high catch rates of legal-sized new-shelled crabs (Fig. 110). Pre-recruit adolescents remained prominent in Conception Bay in 2007, contrasting their low prevalence in Bonavista Bay in the past two years (Fig. 12). This suggests better recruitment prospects in Conception Bay than in Bonavista Bay.

Recruitment prospects are uncertain. Localized DFO trap surveys in two bays indicate that catch rates of new-shelled legal-sized crabs have increased since 2004 and remain high, whereas collaborative trap survey catch rates (Fig. 107) show no trend since 2004.

Mortality

Exploitation: Data are insufficient to estimate fishery-induced mortality indices because no fall trawl survey exploitable biomass is available. However it has been concluded that the exploitable biomass has recently increased. Trap survey catch rates of older-shelled crabs have generally increased since 2004, indicating that the fishery has recently become less dependent upon immediate recruitment. Maintaining the current level of fishery removals would not likely result in an appreciable change in the exploitation rate in 2008.

Indirect fishing mortality: The percentage of the total catch discarded in the fishery (Fig. 113) increased from 1995 to 1997 and decreased sharply in 1998. It remained unchanged until it increased in 2005, and then declined to 16% in 2007, the lowest level since 1995. This implies relatively little wastage of under-sized and new-shelled pre-recruits in the 2007 fishery.

Overall, observed weekly levels of soft-shelled crab were low in 2007, comparable to the levels observed from 2004 to 2006 (Fig. 114). The percentage of soft-shell in the catch increased as the season progressed. It reached 20% in week 15, was unchanged in week 16 and exceeded 50% in week 17, the last week of the season. In all years, soft-shelled crab has consistently constituted only a minor portion of the catch in the early to mid portions of the season in Div. 3L inshore, but prevalence levels tend to increase in the latter part of the season.

Most of the fishery has occurred earlier in the past two years than it had in preceding years (Fig. 115). In 2006, 47% of the effort had been expended by week 7, the point at which the 2005 fishery started. The 2007 fishery was delayed by three weeks in starting relative to 2006, attributable to spring ice conditions. Despite this, the season progressed fairly rapidly. Nearly 100% of the effort was expended by week 18 in the past two years, about a month earlier than in 2003. The weekly distribution of observed sets relative to fishing effort was biased toward early and late-season observer coverage in 2003, but has better reflected the distribution of total fishing effort since 2004 (Fig. 115).

Natural Mortality (BCD): The trend in prevalence of BCD from Conception Bay trap surveys (Fig. 116) is similar to that from the multi-species surveys (Fig. 100), but at higher levels of prevalence, with highest prevalence during 2004-05 Trends in prevalence of BCD in trawl surveys in Conception Bay have been similar to those in the trap surveys, but at lower levels. Prevalence generally increased to 2000 before decreasing sharply in 2001. It increased during 2003-05 before decreasing in 2006. Prevalence further decreased in 2007, to its lowest level since 2003 for all sizes of crab.

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 do not reflect (and have consistently exceeded) TACs because not all fishing has been regulated by TAC. Landings declined by about 28% since 2004 to 3,380 t in 2007 (Table 11, Fig. 117). Effort declined by 23% from 2004-06 and increased by 16% in 2007.

Commercial CPUE (Fig. 118) indicates that fishery performance deteriorated in 2007. The spatial distribution of fishing effort and CPUE has changed in recent years. For example there has been a reduction of effort in Div. 3O since 2004 and an increase in effort along the southern 3N slope in 2007 (Fig. 119).

Biomass

The commercial logbook, observer, and VMS CPUE indices (Fig. 120) all decreased in 2007. Commercial logbook CPUE increased gradually from 1996-1999 and remained unchanged until 2003. It then declined abruptly to a lower level in 2004 and remained stable until 2006, before declining sharply to its lowest level in 2007. Trends in the VMS-based CPUE have agreed with commercial CPUE since 2004. Observer CPUE declined gradually from 2002 to 2004 and remained unchanged until 2006. It declined sharply to its lowest level in 2007.

The spatial coverage of the fishery has generally been inversely related to commercial CPUE since 2002 (Fig. 121). The absence of such a trend prior to 2002 is likely attributable to a period of spatial expansion in the fishery in a region with little available snow crab habitat. The percentage of available 5' x 5' cells occupied by the fishery increased sharply from 3.5% in 1998 to 11.4% in 1999. It has since fluctuated between 7-10% in any given year, with 8% of the available cells fished in 2007.

The fishery in 2006 and 2007 started 2-5 weeks earlier than in the 3 previous years (Fig. 122). This earlier start to the fishery has resulted in prolonged seasons in recent years (Fig. 122). The 2006 and 2007 seasons ended two weeks later than in 2005 and 1-3 weeks later than in 2004 and 2003. The total recorded effort increased to about 350,000 trap hauls in 2007, comparable to the levels of 2004 and 2005.

Trends in commercial logbook CPUE throughout the season (Fig. 123) showed that catch rates, for the past 6 years, were at their lowest level in 2007 throughout most of the season. During 2006 and 2007 CPUE remained constant throughout the season until it declined sharply. Despite the lower catch rate, this occurred later in 2007 (Fig. 123a) and at a higher cumulative catch (Fig. 123b) than in 2006. In 2007, CPUE remained constant at about 14 kg/trap until week 14 (Fig. 123a), or 3000 t (Fig. 123b), when it declined abruptly to about 7-8 kg/trap for the remainder of the season. Trends in seasonal VMS-based CPUE (Fig. 124) exhibited more variability than did logbook CPUE but it did not show CPUE to be lower throughout the season in 2007 than during the three previous years. However, it did similarly show a sharp decline in 2007 CPUE after week 11 (Fig. 124a). In contrast to the logbook CPUE trend this decline continued for the remainder of the season and was evident in 2007 only.

Size distributions from observer sampling in Div. 3NO (Fig. 125) showed a gradual increase in modal CW from 110 mm CW in 2000-01 to 113 mm in 2003. Observed catch rates of most sizes decreased from 2002-04 with a reduction in abundance of old-shelled crabs in the catch, before increasing in 2005-06, due to an increase in old-shelled crabs. The size distributions changed very little from 2005 to 2006, with modal CW at 100 mm, but became platykurtic in 2007, with decreases in catch rates of new and old-shelled crabs across a broad size range between 101-125 mm CW. This decrease in catch rate occurred two years later than that in offshore Div. 3L (Fig. 87). There has been no increase in catch rate of small crabs that might indicate improvement in recruitment prospects. Old-shelled crabs have represented the highest proportion of legal-sized crabs sampled by observers since 2005 (Fig. 126a). Catch rates of new hard-shelled crab have gradually decreased since 1999, to their lowest level in 2007. Soft-shelled crabs have constituted a small portion of the catch throughout the time series. Trends in the catch rates of new hard-shelled and old-shelled legal-sized crab, when combined (exploitable crabs), have generally reflected the retained catch since 2003 (Fig. 126b).

Trends in the exploitable biomass are uncertain. Survey indices (Table 12, Fig. 127) are unreliable because of a limited spatial distribution of the resource within these divisions that is poorly sampled by the multi-species survey. The fall trawl survey was incomplete in 2006 with a few deep strata along the Div. 3NO slope not surveyed.

Production

Recruitment: High annual variability in the biomass index (Fig. 128a) and catch composition (Fig. 128b) by shell condition reflect the unreliability of the trawl survey in this area.

The size distributions from fall multi-species surveys (Fig. 129) further reflect the unreliability of the multispecies trawl survey data. For example, very few large, adult crabs were captured in 2005 and 2006, but in 2007 there was an increase in the abundance index of all crabs across the legal size range (>94 mm CW). It does appear however, that more adolescents achieve legal size before terminally moulting to adulthood in Div. 3NO (Fig. 129) than in Div. 3L (Fig. 93).

Catch rates of discarded crabs have changed little and agreed closely catch rates of under-sized crabs since 2002 (Fig. 130), suggesting low incidence of soft-shelled crab in the Div. 3NO fishery in recent years.

The fall survey pre-recruit index (Table 13, Fig. 131) peaked in 1998, declined to 2002, and has since remained low. However there is high uncertainty in interpreting trends for this area, as noted for the exploitable biomass. Therefore, recent recruitment and future prospects are uncertain.

Reproduction: There was no clear trend in the percentage of females carrying full clutches of viable eggs in Div 3NO (Fig. 132). Almost all females carried full clutches in 1995-1996 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. About 90% of captured mature females carried full clutches in 2007.

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. The effects of maintaining the current catch level on the fishery-induced mortality rate are unknown.

Indirect fishing mortality: The percentage of the total catch discarded in the fishery (Fig. 133) declined by more than half from 1999 to 2002. It has remained steady during the last 6 years at a low level, implying little wastage of pre-recruits in the fishery in recent years.

The observed weekly prevalence of soft-shelled crab (Fig. 134) has been consistently low in Div. 3NO, but late-season levels have increased slightly in the past two years. In 2006, maximum weekly soft-shelled crab prevalence throughout the season never exceeded 20% but was at about 15% for two weeks late in the season (weeks 16 and 18) In 2007, prevalence peaked at 14% in week 14 of the fishery but was below 6% in all other weeks.

The seasonal fishing pattern (Fig. 135) was similar to that in offshore Div. 3L (Fig. 99), in that fishery started earlier and was more prolonged in 2006 and 2007 (Fig. 135) than in previous years. The Div. 3NO fishery spanned 18 weeks in 2006 and 2007. Despite the prolonged fishing season, soft-shelled crab catch rates have remained at low levels in all weeks in all years. Most of the 2007 fishery occurred uniformly in weeks 3 through 16, with 91% of the trap hauls in this period. The weekly distribution of observed sets has agreed well with that of total fishing effort since 2004, but especially during 2007

Natural Mortality; BCD: BCD has been virtually absent from Div. 3NO, based on fall multi-species survey trawl samples.

SUBDIVISION 3Ps

The Fishery

The fishery began in 1985 and was limited to the inshore until the early 1990's. Landings (Table 14, Fig. 136) increased sharply from the early 1990's to 1995 with expansion of the fishery into the offshore. Landings from offshore areas have been about twice as high as those from inshore areas in recent years. Landings from both inshore and offshore were at their highest level during 1999-2002.

Offshore landings (Fig. 136) increased by 21% to 2800 t in 2007, following a 47% decline from 2002 to 2006. Effort (Fig. 136) increased by 16% in 2007, following a 32% decrease from 2003 to 2006 (Fig. 136).

Inshore landings (Fig. 136) declined by 79% to their lowest level from 2002 to 2005 and have since increased by 63% to 1150 t in 2007. Effort (Fig. 136) decreased by about half from 2003 to 2005 and changed little since.

CPUE trends (Fig. 137) indicate that fishery performance has changed little over the past four years offshore whereas it has improved slightly inshore in the past two years. CPUE has consistently been higher offshore than inshore. Spatially, increases in CPUE were most evident in the inshore part of the Subdivision in 2007 (Fig. 138). In the offshore, the spatial distribution of fishing effort changed little in recent years but there was virtually no fishery on the north-west slope of St. Pierre bank during 2005-07 as there was in 2002-04. In the inshore, the distribution of fishing effort between Fortune and Placentia Bays varied among years.

Effect of ocean climate variation

Bottom temperature in Subdiv. 3Ps, at a seven year lag, has been inversely related to commercial CPUE since 1985 (Fig. 139). Bottom temperature and CPUE increased in 2006 and 2007 while CPUE increased marginally but remained low.

SUBDIVISION 3Ps OFFSHORE

Biomass

The commercial logbook and observer CPUE indices (Fig. 140) have trended together since 1999. Both declined steadily from 1999 to 2003, and have since remained at a low level. The VMS-based CPUE trend has agreed with the logbook and observer CPUE trends since 2004, changing little in the past four years.

The spatial coverage of the fishery has generally been inversely related to commercial CPUE since 1999 (Fig. 141). The percentage of available 5' x 5' cells occupied by the fishery increased steadily from 1995 to an initial peak in 2002. It then declined gradually in 2003 and 2004 before increasing sharply to its highest level of 75% in 2005. This is likely attributable to a high incidence of soft-shelled crab in the fishery in 2005 (Dawe et al. 2006). The spatial index declined sharply in 2006 and was unchanged in 2007 with 51% of the available cells occupied by the fishery, while CPUE increased gradually in the past two years, from its lowest level in 2005. The Subdiv. 3Ps offshore fishery primarily occurs around the bases of St. Pierre and Green Banks (Fig. 138) with smaller amounts of effort along the north-west slope of the St. Pierre Bank in some years.

The fishery in offshore Subdiv. 3Ps has occurred much earlier in the past two years than during 2003-05. The timing and scale of the 2007 fishery was similar to that of 2006 (Fig. 142). The 2007 fishery started in the first week of April and lasted 13 weeks. The fishery has started four to six weeks earlier in the past two years than it did in earlier years, and has (excepting 2005) ended progressively earlier since 2003. The level of recorded effort in logbooks has decreased from about 375,000–425,000 trap hauls in 2003-05 to about 300,000 trap hauls in 2006 and 2007 (Fig. 142).

Trends in commercial logbook CPUE throughout the season (Fig. 143) showed a decrease from the early to mid-portions of the season each year from 2002 to 2005. More recently, this decrease (from week 3, Fig. 143a) has been very slight in 2006 and virtually absent in 2007. This suggests little depletion by the fishery in 2007. Seasonal VMS-based CPUE trends (Fig. 144) were similar to those from logbooks, with no apparent seasonal decline in CPUE in 2007 relative to the previous three years (Fig. 144).

Size distributions from at-sea sampling by observers (Fig. 145) show a sharp ('knife-edge') decrease in catch rate at 95mm CW since 2004, suggesting high exploitation of legal-sized crabs, including new-shelled immediate pre-recruits. Catch rates of legal-sized old-shelled crabs decreased sharply for most sizes of crab in 2003 and remained low until 2004 as the distributions became increasingly platykurtic. However, since 2005, there has been an increase in catch rates of most sizes of old-shelled crabs from 89 mm to 104 mm CW, likely reflecting the progression of a modal group of adolescent pre-recruits observed in spring trawl survey size distributions in 2005 (Dawe et al. 2006). The high catch rates of undersized (<95 mm CW) crabs in most years and the high proportion of those that were old shelled, suggests that crabs terminally molt to adulthood at small sizes in Subdiv. 3Ps relative to other areas.

Observed catch rates of legal-sized old-shelled animals (Fig. 146a) declined sharply in 2003 and have since varied without trend. Observed catch rates of new-hard-shelled animals declined sharply two years earlier, in 2001, and have since remained at a low level. Catch rates of old-shelled crabs have consistently been higher than those of new-hard-shelled crabs, and catch rates of soft-shelled crabs have been minimal each year with the exception of 2005. Trends in the levels of intermediate and old-shelled legal-sized crab, when combined (exploitable crabs), have reflected the retained catch since 2000, with particularly tight agreement since 2003 (Fig. 146b).

The exploitable biomass remains at a very low level. The spring survey exploitable biomass index (Table 15, Fig. 147) declined from 1999 to 2001, and has since remained unchanged. CPUE decreased steadily from 1999 to 2003 and has since remained at a low level (Fig. 137). However, the post-season collaborative trap survey catch rates of legal-sized crabs increased from 2004 to 2006 and were unchanged in 2007 (Fig. 148).

Production

Recruitment: Recruitment has been low in recent years, as reflected by the low exploitable biomass (Fig. 147) while landings remained relatively low following a decline (Fig. 136). The spring survey biomass index of new-shelled legal-sized crabs has remained low following a decline during 1996-2001 (Fig. 149).The high biomass of new-shelled crabs in 1996, the first year of the spring multi-species trawl survey (Fig. 149a), was followed by a peak in both intermediate and old-shelled crabs three years later in 1999, but low biomass levels for all groups of crabs in the index since 2000 make annual changes in biomass by shell condition difficult to interpret. However, there has been a reduction in the proportion of old-shelled animals in the survey in recent years (Fig. 149b).

Trends in catch rates of new-shelled legal-sized crabs from common stations in the collaborative survey have been variable by year (Fig. 148), with peak abundance in 2006. Catch rates of legal-sized old-shelled crabs increased in 2005 and remained higher than the 2004 level since. Size distributions showed a substantial increase in catch rates of sub-legal-sized crabs in 2005 and an increase in catch rates of most sizes of new and old-shelled legal-sized crabs in 2006 (Fig. 150), with little change in 2007. The high catch rates of undersized (<95 mm CW) crabs in most years and the high proportion of those that were old shelled (Fig. 150), relative to some other areas such as Div. 3K offshore (Fig. 49) supports our earlier suggestion that crabs terminally molt to adulthood at small sizes in Subdiv. 3Ps relative to other areas.

Size distributions from the spring trawl survey reflect the presence of a modal group of adolescents first observed in 2005 at a modal size of about 65 mm CW (Fig. 151). These adolescents achieved a modal size of about 80 mm CW in 2007 (Fig. 151) and so are expected to achieve legal size and subsequently recruit to the exploitable biomass over the next several years. It is apparent (e.g. in 1999, Fig. 151) that a very low proportion of crabs enter legal size as adolescents in Subdiv. 3Ps relative to some other areas (such as Div. 3NO, Fig. 129), supporting our assertion that male crabs terminally molt to adulthood at relatively small size in this area.

This represents the only area where the observer catch rate of under-sized discards (from at-sea sampling) commonly exceeds that of total discards (from set and catch data) (Fig. 152). This indicates that either the under-sized discards are over-estimated or the total discards are under-estimated. However, that this is unique to Subdiv. 3Ps also suggests that under-sized discards represents a higher proportion of the total discards in Subdiv. 3Ps than in other divisions. Trends in the observed catch rates of under-sized crabs have generally tracked those of total discards up to 2005, suggesting that the ratio of under-sized to soft-shelled discards has changed little during that time. The catch rate of total discards exceeded that of under-sized discards only in 2005, implying a high incidence of soft-shelled crab in the catches during that year. The catch rate of under-sized crabs has increased marginally since 2005 while total discards have decreased, suggesting that there has been a decrease in the proportion of soft-shelled crabs in the discards since 2005.

Recruitment is expected to increase over the next several years. The spring multi-species survey pre-recruit index (Table 16, Fig. 153) increased in 2007 to its highest level since 1996.

Reproduction: No data.

Mortality

Exploitation: No exploitation rate index or pre-recruit fishing mortality index have been developed using spring trawl survey data. Also, the 2006 survey was incomplete, thus no 2007 indices could be derived from the data. Increased removals, under the present scenario of very low biomass and imminent recruitment increase, could result in increased mortality on soft-shelled immediate pre-recruits.

Indirect fishing mortality: The percentage of the total catch discarded in the fishery (Fig. 154) almost doubled to about 45% in 2005 and declined but remained high in 2006 and 2007. This implies a high level of wastage of pre-recruits in recent years.

With the exception of 2005, the observed prevalence of soft-shelled crab in the weekly catches has remained low since 2002 (Fig. 155). In 2007, soft-shelled prevalence was below 2% in all weeks except week 10, the last week of the season, where it comprised 15% of the catch.

The fishery started and ended earlier in 2006 and 2007 than in previous years (Fig. 156). Effort expenditure was highest from weeks 3 to 8 of the 2007 fishery, with 79% of the effort occurring during this period. Similarly, 86% of the observed sets occurred during this period. Soft-shelled crab catch rates have remained at low levels in most weeks during the past two years. The distribution of observed sets has generally reflected that of total fishing effort, since 2005.

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 offshore Subdiv. 3Ps in 2005-06, but not in 2007 (unpublished data).

SUBDIVISION 3Ps INSHORE

Biomass

The commercial logbook and observer CPUE indices (Fig. 157) both increased in 2007. Commercial logbook CPUE declined from 2001 to a record low level in 2004-05 before increasing slightly in 2006 and 2007. Similarly, observer CPUE declined sharply from 2001 to 2003 and increased slightly in 2006 and 2007. However, an anomalous peak occurred in 2004 in the observer index, inconsistent with the trend in commercial CPUE for that year. This anomaly could be attributable to a low level of observer coverage or spatial or temporal bias in observer deployments in 2004.

The spatial coverage of the fishery has been inversely related to commercial CPUE since 1995 (Fig. 158). The percentage of available 5' x 5' cells occupied by the fishery increased steadily from 1995 to an initial peak of 23% in 2000. Conversely, CPUE declined by 44% during this period. A sharp increase in CPUE in 2001 contrasted a sharper decrease in spatial coverage of the fishery. CPUE then decreased abruptly in 2002 while the spatial coverage of the fishery sharply increased back to the 2000 level. Since 2004-05, the slight increase in CPUE has been associated with a gradual decrease in the percentage of available cells occupied by the fishery. The Subdiv. 3Ps inshore fishery primarily occurs in Placentia Bay to the East, with smaller amounts of effort in Fortune Bay to the west (Fig. 138).

The fishery in inshore Subdiv. 3Ps has occurred progressively earlier since 2003 (Fig. 159). The 2007 season started in the first week of April and was completed by week 17, one week earlier than the 2005-06 seasons.

Trends in commercial CPUE throughout the season (Fig. 160) indicated that CPUE was higher throughout the season in 2007 than in 2006. A pattern of late-season depletion was evident during 2002-05, following a peak that occurred within weeks 8-10 (Fig. 160a). This peak corresponded to a cumulative catch of about 500 t during 2002-04, whereas it occurred at a much smaller cumulative catch in 2005 (Fig. 160b). Such a peak in CPUE and subsequent depletion was not evident in 2007, as CPUE varied at about 6 kg/trap throughout the season.

Size distributions from at-sea sampling by observers (Fig. 161) showed an increasingly sharp ('knife-edge') decrease in catch rate at 95 mm CW from 2001 to 2006, reflecting effects of high exploitation on legal-sized crabs including new-shelled immediate pre-recruits. This knife-edge effect was less prominent in 2007 than in 2006, due to increase in catch rate of small legal-sized crabs (95-98 mm CW, Fig. 161). This is consistent with the progression of a modal group of adolescent pre-recruits observed in the offshore spring trawl survey size distributions in 2005 (Dawe et al. 2006). Catch rates of largest crabs greater than 101 mm CW of all shell conditions were lower in 2006 and 2007 than in all pervious years, consistent with the high exploitation on commercial-sized animals.

Peaks in observed catch rates of old-shelled legal-sized crabs have not been preceded by peaks in catch rates of new-shelled legal-sized crabs as in some other divisions, but rather tended to trend together (Fig. 162a). This may reflect subjectivity in classification of shell categories by observers. Catch rates of soft-shelled crab constituted 0-1% of the catch since 2000, excepting a sharp increase to 3% in 2005. Trends in catch rates of new-hard and old-shelled legal-sized crab, when combined, have reflected the retained catch throughout most of the time series (Fig. 162b). Disagreement between these catch rates especially during 2004 and 2005 could be due to low levels of observer coverage, spatial or temporal variation in observer sampling, or classification of some soft-shelled crabs as new-hard-shelled. Observed catch rates of soft-shelled crabs have been low throughout the time series, with a peak (exceeding 2 kg/trap haul) in 2005.

The exploitable biomass remains low. CPUE declined from 2001 to its record low level in 2004-05 before increasing slightly in 2006 and 2007 (Fig. 157). The collaborative trap survey catch rates of legal-sized crabs increased slightly from 2004 to 2007 (Fig. 163).

Production

Recruitment: Recruitment increased slightly in 2007, as reflected by the slight increase in CPUE (Fig. 157) while landings increased (Fig. 136) and by the slight increase in the collaborative trap survey catch rate of legal-sized crabs (Fig. 163).

Trends in catch rates of new-shelled legal-sized crabs from common stations in the collaborative survey increased in 2005, were unchanged in 2006, and increased further in 2007 (Fig. 163). The increase in 2005 agrees with the increase in soft-shelled crabs from observer at-sea sampling (Fig. 162). Size distributions showed a substantial increase in catch rates across all sizes and shell categories in 2007 (Fig. 164) . Soft-shelled crabs were most prevalent at sizes of 100-104 mm CW, as also observed offshore (Fig.150).

Trends in the observed catch rates of under-sized crabs have differed from the catch rates of total discards since 2004 (Fig. 165). The catch rate of under-sized crabs has increased since 2004 while total discards increased sharply in 2005 and have since remained high but declined slightly. Total discards exceeded under-sized discards in most years, whereas the reverse was true in the offshore (Fig. 152). The high level of total discards in 2005, especially in relation to under-sized discards reflects the prominence of soft-shelled crab in the catches during that year, as noted from observer at-sea sampling (Fig. 161-162).

Recruitment prospects remain positive in the short term. The trap survey catch rates of legal-sized new-shelled crabs and sub-legal-sized (under-sized) crabs have increased since 2004 (Fig. 163). Also, the catch rate of under-sized crabs from observer at-sea sampling has increased steadily since 2002 (Fig. 165).

Reproduction: No data.

Mortality

Exploitation: Data are insufficient to estimate fishery-induced mortality indices because no spring trawl survey exploitable biomass is available for this inshore area. Although recruitment and the exploitable biomass have increased slightly, it has been concluded that the exploitable biomass remains low. Increased removals, while the exploitable biomass remains low and recruitment is increasing, could result in increased mortality on soft-shelled immediate pre-recruits.

Indirect fishing mortality: The percentage of the total catch discarded in the fishery (Fig. 166) was at its highest, about 60%, in 2005 and 2006. It decreased to remain high, at 47%, in 2007. This implies a high level of wastage of pre-recruits in recent years.

The observed percentage of soft-shelled crab in the catch (Fig. 167) remained low in all weeks of both 2006 and 2007. Generally, soft-shelled catch rates have been very low in Subdiv. 3Ps inshore. However soft-shelled crab prevalence has exceeded 20% during some weeks in 2002-2003 and 2005. In 2002 soft-shelled crab prevalence exceeded 50% for four weeks in the mid-latter parts of the season and in 2005 prevalence varied between 10-40% for much of the season.

The fishery has occurred earlier in the past two years than in previous years (Fig. 168). Although the 2003 fishery started in the first week of April, it did not conclude until week 23. By contrast, most of the effort was expended by week 10 in the past two years. In 2007, 93% of the fishing effort occurred from weeks 1 to 10. There was some bias in observer coverage toward the latter portion of the season in 2007, as 26% of the observed sets occurred after week 10. The distribution of observer coverage has not well reflected that of total fishing effort in most years in Subdiv. 3Ps inshore. In earlier years, observer coverage was relatively high in the early season, while in 2007, it was higher late in the season. This could potentially result in bias in interpreting soft-shelled crab prevalence in the fishery in this area.

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 in 2003-2006 but not in 2007 (unpublished data).

DIVISION 4R AND SUBDIVISION 3Pn

The Fishery

Landings (Table 17, Fig. 169) have generally been comparable between inshore and offshore areas. TACs have not been taken since 2002. Offshore landings (Fig. 169) decreased from 750 t in 2001 to 80 t in 2006 before increasing to 190 t in 2007. Effort declined by 86% during 2005-2006 and increased in 2007. Inshore landings (Fig. 169) declined by 65% since 2002 to a record low of 370 t in 2007. Effort decreased sharply in 2005 and changed little since.

CPUE (Fig. 170) is higher in inshore than in offshore areas but is low relative to other divisions. The spatial distribution of fishing effort and CPUE (Fig. 171) has changed substantially since 2002. Effort has become highly aggregated, both offshore and inshore, within a few localized areas. CPUE has declined steadily since 2002 to record low levels in both offshore and inshore areas (Fig. 170), but annual variability in spatial distribution of effort confounds interpretation of these trends.

DIVISION 4R AND SUBDIVISION 3Pn OFFSHORE

There are insufficient data to assess resource status.

Biomass

It is not possible to infer trends in exploitable biomass from commercial CPUE data (Fig. 172) because of recent changes in the spatial distribution (steady contraction) of fishing effort (Fig. 171). In contrast to other areas, CPUE and the spatial extent of the fishery have generally been directly related since 1995 (Fig. 173). Both CPUE and the spatial extent of the fishery have declined from the 2000-02 levels (Fig. 173). In 2007, CPUE was below 3 kg/trap, while only 9% of the available 5’ x 5’ cells were fished.

The fishery has occurred progressively earlier in recent years (Fig. 174). The fishery has been concluded by weeks 13-14 in the past two years, whereas in the previous three years it did not conclude until weeks 25-27. The scale of the fishery has also decreased in the past two years. In 2006 and 2007, there were about 30,000 and 45,000 recorded trap hauls respectively whereas in the previous three years recorded effort ranged from about 95,000–150,000 trap hauls.

Annual trends in CPUE are influenced by the spatial contraction of the fishery. However, commercial logbook CPUE (Fig. 175) and VMS-based CPUE (Fig. 176) have been at their lowest levels throughout the season during the past two years.

Production

Recruitment: There are no data available that could be used to infer recruitment. Therefore, short-term recruitment prospects are unknown.

Reproduction: No data.

Mortality

Exploitation: Trends in fishing mortality on either the exploitable or pre-recruit population are unknown.

Indirect fishing mortality: The observer data are insufficient to estimate the percentage of the catch discarded in the fishery or to infer wastage of pre-recruits.

Natural Mortality (BCD): No data.

DIVISION 4R AND SUBDIVISION 3Pn INSHORE

Biomass

Both CPUE and the spatial extent of the fishery increased sharply in 2002 (Fig. 177), but both indices have since steadily declined.

The fishery has occurred progressively earlier in recent years (Fig. 178). The fishery has been concluded by weeks 14-17 in the past two years, whereas in the previous three seasons it did not conclude until weeks 22-27. The scale of the fishery has also decreased in the past three years. From 2005 to 2007, there were about 40,000–60,000 recorded trap hauls whereas in the previous two years there were about 80,000–85,000 trap hauls.

Annual trends in CPUE are influenced by the spatial contraction of the fishery. However, commercial logbook CPUE (Fig. 179) was at its lowest level throughout the season during 2007.

Biomass has recently declined. Both CPUE (Fig. 177) and post-season trap survey catch rates of legal-sized crabs from common stations (Fig. 180) have declined sharply since 2005.

Production

Recruitment: Recruitment has declined in 2006 and 2007, as reflected by the decline in the exploitable biomass while landings declined (Fig. 169). Collaborative trap survey catch rates of new-shelled legal-sized crabs (Fig. 180) have decreased since 2005. Recruitment prospects are unknown.

Reproduction: No data.

Mortality

Exploitation: Maintaining the current level of fishery removals would likely result in an increase in the exploitation rate in 2008.

Indirect fishing mortality: The observer data are insufficient to estimate the percentage of the catch discarded in the fishery or to infer wastage of pre-recruits.

Natural Mortality (BCD): No data.

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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	69,030
2000	51,169	55,362
2001	52,252	56,714
2002	56,981	59,397
2003	56,330	58,326
2004	53,590	55,586
2005	49,978	43,882
2006	46,233	47,063
2007	47,663	49,996

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

Year	TAC	Landings	Effort	CPUE
1985		332	24,776	13.4
1986	925	468	38,361	12.2
1987	925	232	25,778	9.0
1988	926	456	50,667	9.0
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	9.0
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	5,416	401,185	13.5
2000	3,411	3,685	304,545	12.1
2001	3,340	3,738	424,773	8.8
2002	3,381	3,521	577,213	6.1
2003	2,265	2,511	583,953	4.3
2004	1,780	1,915	531944	3.6
2005	1,425	1,517	286,226	5.3
2006	1,425	1,987	242,317	8.2
2007	1,570	2,330	270,930	8.6

Table 3. Fall trawl survey exploitable Biomass index by year for Division 2J, with 95% confidence intervals and mean catch rate.

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	3,367	4,742	1,991	1.13
1996	5,546	7,655	3,437	1.87
1997	10,196	16,238	4,155	3.43
1998	12,376	18,154	6,598	4.17
1999	6,117	8,159	4,075	2.06
2000	3,506	4,437	2,574	1.18
2001	3,161	3,775	2,346	1.06
2002	798	1,283	314	0.27
2003	945	1,600	291	0.32
2004	1,389	2,070	709	0.47
2005	2,005	10,441	-6,431	0.68
2006	2,317	3,066	1,569	0.78
2007	2,547	4,176	918	0.86

Table 4. Fall trawls survey pre-recruit Biomass index by year for Division 2J, with 95% confidence intervals and mean catch rate.

YEAR	BIOMASS (t)	Confidence Intervals (+/-)		MEAN kg/set
		Upper	Lower	
1995	1,937	2,832	1,042	0.65
1996	2,339	3,467	1,211	0.79
1997	2,783	4,182	1,384	0.94
1998	3,384	4,523	2,244	1.14
1999	1,082	1,999	165	0.36
2000	1,211	1,759	663	0.41
2001	1,254	3,095	-587	0.42
2002	547	2,992	-1,897	0.18
2003	835	1,224	426	0.28
2004	4,716	34,239	-24,806	1.59
2005	1,542	3,591	-507	0.52
2006	1,715	3,575	-144	0.58
2007	1,153	280	-493	0.39

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

Year	TAC Inshore	Landings Inshore	Effort Inshore	CPUE Inshore	TAC Offshore	Landings Offshore	Effort Offshore	CPUE Offshore
1990				6.9				14.9
1991				9.5				15.0
1992				9.5				13.4
1993				10.5				16.3
1994				9.1				15.4
1995	1,950	1,950	237,805	8.2	9,500	10,376	741,143	14.0
1996	3,450	3,267	510,469	6.4	9,500	10,943	835,344	13.1
1997	3,450	3,122	538,276	5.8	10,850	11,674	871,194	13.4
1998	3,040	2,781	487,895	5.7	12,700	14,058	943,490	14.9
1999	3,242	3,460	865,000	4.0	14,950	17,926	1,347,820	13.3
2000	2,275	2,328	485,000	4.8	11,218	13,062	1,187,455	11.0
2001	2,475	2,464	273,778	9.0	11,218	12,824	1,282,400	10.0
2002	2,945	3,118	384,938	8.1	12,433	13,234	1,225,370	10.8
2003	3,175	3,339	498,358	6.7	12,433	13,163	1,265,673	10.4
2004	3,120	3,264	615,849	5.3	12,473	13,196	1,736,316	7.6
2005	2,885	2,589	550,851	4.7	9,975	6,096	870,857	7.0
2006	2,485	2,617	408,906	6.4	7,945	8,100	704,348	11.5
2007	2,620	2,819	290,619	9.7	9,130	9,451	630,067	15.0

Table 6. Fall trawl survey exploitable Biomass index by year for Division 3K, with 95% confidence intervals and mean catch rate.

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	10,073	12,679	7,467	2.06
1996	19,373	23,470	15,276	3.97
1997	18,486	22,667	14,306	3.79
1998	18,457	22,938	13,976	3.84
1999	8,408	10,919	5,898	1.72
2000	9,791	12,192	7,390	2.01
2001	11,143	15,688	6,599	2.28
2002	8,615	11,232	5,998	1.76
2003	3,567	4,555	2,579	0.73
2004	5,479	6,938	4,020	1.12
2005	6,733	8,584	4,883	1.38
2006	10,310	12,601	8,020	2.11
2007	15,801	21,175	10,427	3.24

Table 7. Fall trawl survey pre-recruit Biomass index by year for Division 3K, with 95% confidence intervals and mean catch rate.

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	6,413	8,932	3,893	1.31
1996	10,010	13,648	6,372	2.05
1997	12,880	17,255	8,505	2.64
1998	9,790	13,861	5,720	2.03
1999	3,400	4,811	1,990	0.70
2000	8,925	12,365	5,485	1.83
2001	6,287	8,517	4,058	1.29
2002	4,796	6,852	2,740	0.98
2003	2,340	4,193	488	0.48
2004	5,416	9,200	1,631	1.11
2005	5,678	7,835	3,521	1.16
2006	9,582	14,671	4,494	1.96
2007	4,972	6,826	3,119	1.02

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

Year	TAC Inshore	Landings Inshore	Effort Inshore	CPUE Inshore	TAC Offshore	Landings Offshore	Effort Offshore	CPUE Offshore
1990				7.3				8.4
1991				6.9				10.2
1992				10.9				14.6
1993				11.7				16.0
1994				14.4				16.2
1995	6,475	6,795	471,875	14.4	5,175	7,212	389,838	18.5
1996	7,675	7,922	665,714	11.9	7,100	8,494	534,214	15.9
1997	5,850	6,398	627,255	10.2	13,075	14,293	893,313	16.0
1998	7,225	6,879	582,966	11.8	12,750	16,410	948,555	17.3
1999	5,350	5,453	482,566	11.3	21,025	20,767	1,173,277	17.7
2000	4,633	4,731	407,845	11.6	18,077	17,869	930,677	19.2
2001	5,615	5,546	518,318	10.7	18,040	17,923	958,449	18.7
2002	6,540	6,525	582,589	11.2	19,908	18,488	1,010,273	18.3
2003	6,774	6,818	841,728	8.1	21,033	19,228	1,158,313	16.6
2004	6,255	6,421	823,205	7.8	21,033	19,325	1,351,399	14.3
2005	6,045	6,114	745,610	8.2	21,033	18,795	1,352,158	13.9
2006	6,095	6,229	648,854	9.6	21,033	20,250	1,511,194	13.4
2007	6,105	6,485	600,463	10.8	21,033	20,353	1,739,573	11.7

Table 9. Fall trawl survey exploitable Biomass index by year for Division 3L, with 95% confidence intervals and mean catch rate (Survey was incomplete in 2004).

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	19,527	25,572	13,482	3.39
1996	31,093	38,009	24,176	5.36
1997	18,577	24,107	13,046	3.20
1998	22,054	28,023	16,085	3.80
1999	12,197	15,515	8,879	2.10
2000	9,101	13,256	4,947	1.57
2001	11,577	15,429	7,725	2.00
2002	11,044	16,243	5,845	1.90
2003	9,456	13,202	5,709	1.63
2004				
2005	9,403	18,172	634	1.63
2006	3,800	5,101	2,500	0.66
2007	6,164	8,210	4,118	1.06

Table 10. Fall trawl survey pre-recruit Biomass index by year for Division 3L, with 95% confidence intervals and mean catch rate (survey was incomplete in 2004).

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	9,061	12,743	5,379	1.57
1996	25,343	33,387	17,298	4.37
1997	8,011	10,736	5,286	1.38
1998	8,507	11,163	5,851	1.47
1999	4,454	6,708	2,200	0.77
2000	4,623	7,222	2,024	0.80
2001	2,916	4,587	1,245	0.50
2002	2,205	3,004	1,407	0.38
2003	4,278	6,842	1,713	0.74
2004				
2005	2,746	4,910	582	0.48
2006	1,488	2,077	899	0.26
2007	5,860	8,265	3,456	1.01

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

Year	TAC	Landings	Effort	CPUE
1985		7		
1986				
1987				
1988		327		
1989		531		
1990		78		
1991		19		
1992				
1993		148		
1994		106		
1995		14	615	
1996		427	33,126	13.1
1997		1,454	99,453	14.6
1998		730	40,176	17.9
1999	3,250	6,506	337,623	19.3
2000	2,425	4,173	216,330	19.3
2001	2,425	4,697	240,010	19.4
2002	2,425	5,023	245,864	20.2
2003	2,670	5,592	293,543	19.1
2004	2,670	5,283	345,294	15.3
2005	2,670	4,740	336,170	14.1
2006	2,670	4,238	275,195	15.4
2007	2,670	4,057	329,837	12.3

Table 12. Fall trawl survey exploitable Biomass index by year for Division 3NO; with 95% confidence intervals and mean catch rate (Survey was incomplete in 2006).

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	3,009	4,561	1,456	0.70
1996	7,775	12,351	3,199	1.81
1997	5,975	8,791	3,158	1.39
1998	12,598	24,382	814	2.93
1999	9,893	15,864	3,922	2.25
2000	5,560	8,977	2,144	1.29
2001	10,191	16,293	4,089	2.37
2002	4,980	7,528	2,432	1.16
2003	4,609	7,156	2,062	1.07
2004	5,206	10,965	-552	1.21
2005	997	1,751	243	0.23
2006				
2007	2,264	6,690	-216	0.53

Table 13. Fall trawl survey pre-recruit Biomass index by year for Division 3NO; with 95% confidence intervals and mean catch rate (Survey was incomplete in 2006).

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1995	2,903	18,488	-12,683	0.67
1996	8,346	22,603	-5,910	1.94
1997	7,067	48,196	-34,062	1.64
1998	11,506	69,380	-46,368	2.67
1999	8,806	22,905	-5,292	2.00
2000	4,187	7,839	536	0.97
2001	5,066	7,642	2,490	1.18
2002	2,114	4,902	-673	0.49
2003	2,134	3,755	513	0.50
2004	1,369	12,217	-9,479	0.32
2005	425	987	-138	0.10
2006				
2007	1,453	3,599	-693	0.34

Table 14. TAC (t), Landings (t), Effort (trap hauls) and CPUE (kg/trap) by year for Subdivision 3Ps inshore and offshore.

Year	TAC Inshore	Landings Inshore	Effort Inshore	CPUE Inshore	TAC Offshore	Landings Offshore	Effort Offshore	CPUE Offshore
1990				4.7				
1991				4.5				
1992				8.8				
1993				10.2				22.3
1994				13.3				21.4
1995	1,200	1,035	161,719	6.4	525	894	45,846	19.5
1996	1,350	1,309	73,955	17.7	1,700	1,665	99,701	16.7
1997	2,400	2,305	187,398	12.3	2,200	2,370	117,910	20.1
1998	2,300	3,367	333,366	10.1	3,700	3,257	134,033	24.3
1999	3,542	3,598	342,667	10.5	4,417	4,307	177,975	24.2
2000	3,300	3,500	350,000	10.0	4,400	4,387	212,961	20.6
2001	3,200	3,436	279,350	12.3	4,400	4,403	271,790	16.2
2002	3,200	3,280	410,000	8.0	4,400	4,357	360,083	12.1
2003	2,520	2,365	414,912	5.7	3,565	3,748	451,566	8.3
2004	1,630	1,302	372,000	3.5	2,765	3,418	421,975	8.1
2005	1,300	705	207,353	3.4	2,800	2,464	397,419	6.2
2006	975	782	200,513	3.9	2,070	2,317	308,933	7.5
2007	975	1,147	212,407	5.4	2,270	2,800	358,974	7.8

Table 15. Spring trawl survey exploitable Biomass index by year for Subdivision 3Ps, with 95% confidence intervals and mean catch rate (survey was incomplete in 2006).

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1996	4,350	7,633	1,066	1.69
1997	1,111	1,684	539	0.43
1998	1,561	2,382	739	0.61
1999	2,438	4,090	786	0.95
2000	878	1,356	401	0.33
2001	491	779	204	0.19
2002	367	561	174	0.14
2003	419	1,156	-318	0.16
2004	194	293	94	0.08
2005	490	884	96	0.19
2006				
2007	207	364	50	0.08

Table 16. Spring trawl survey pre-recruit Biomass index by year for Subdivision 3Ps, with 95% confidence intervals and mean catch rate (survey was incomplete in 2006).

YEAR	BIOMASS (t)	CONFIDENCE INTERVALS (+/-)		MEAN kg/set
		Upper	Lower	
1996	1,742	3,563	-793	0.68
1997	278	531	26	0.11
1998	650	1,175	124	0.25
1999	300	459	142	0.12
2000	202	392	13	0.08
2001	290	610	-30	0.11
2002	281	452	110	0.11
2003	79	175	-17	0.03
2004	186	312	59	0.07
2005	427	619	235	0.17
2006				
2007	709	1,657	-239	0.28

Table 17. TAC (t), Landings (t), Effort (trap hauls) and CPUE (kg/trap) by year for Division 4R3Pn inshore and offshore.

Year	TAC Inshore	Landings Inshore	Effort Inshore	CPUE Inshore	TAC Offshore	Landings Offshore	Effort Offshore	CPUE Offshore
1993				4.9				
1994				6.5				5.0
1995	1,524	726	100,833	7.2	150	143	26,481	5.4
1996	644	563	104,259	5.4	645	275	74,324	3.7
1997	745	653	112,586	5.8	645	274	83,030	3.3
1998	665	609	112,778	5.4	645	451	121,892	3.7
1999	685	982	160,984	6.1	645	615	146,429	4.2
2000	785	865	173,000	5.0	645	762	152,400	5.0
2001	731	929	172,037	5.4	808	754	171,364	4.4
2002	1,074	1050	120,690	8.7	675	801	160,200	5.0
2003	1,050	950	117,284	8.1	845	612	170,000	3.6
2004	1,026	878	139,365	6.3	838	584	182,500	3.2
2005	1,000	513	81,429	6.3	845	349	109,063	3.2
2006	860	462	85,556	5.4	675	81	23,143	3.5
2007	750	368	83,636	4.4	540	186	68,889	2.7

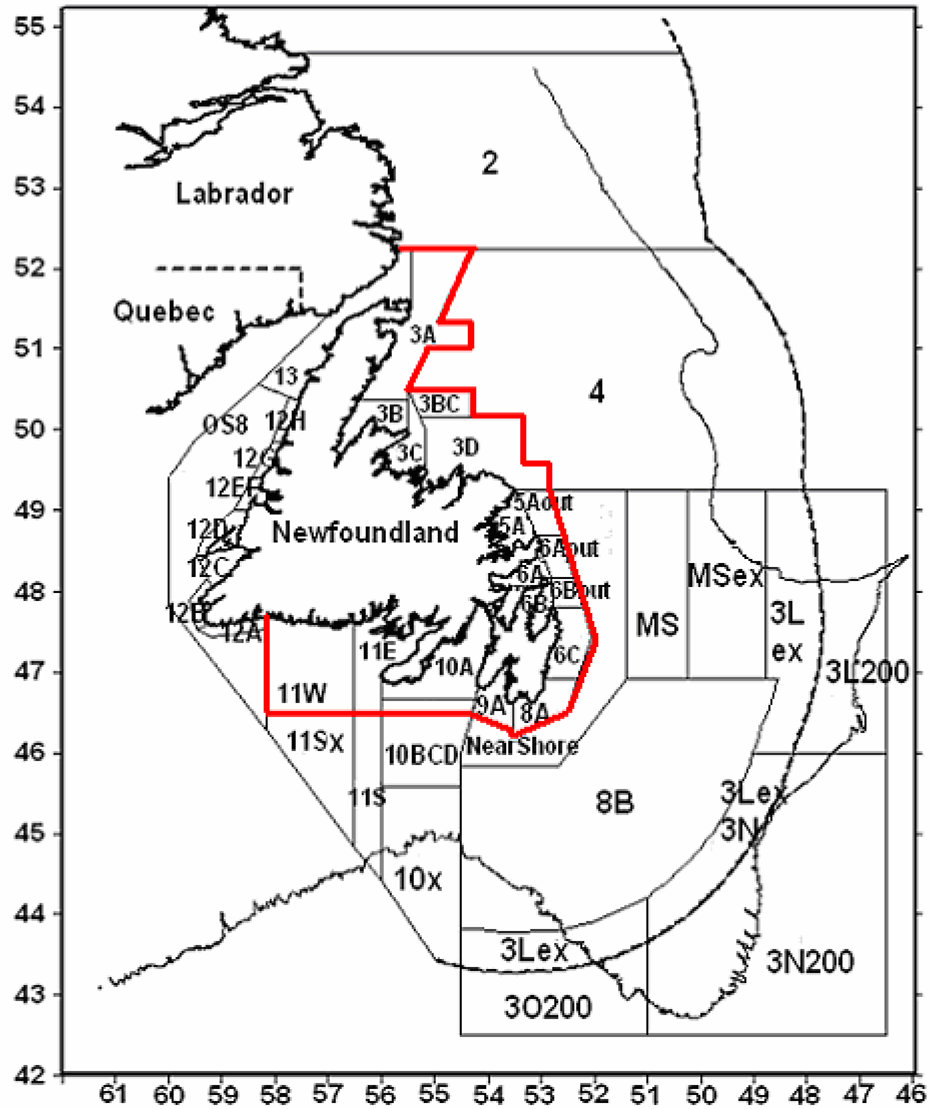


Figure 1. Newfoundland and Labrador snow crab management areas. (Red line shows division of inshore vs. offshore CMAs)

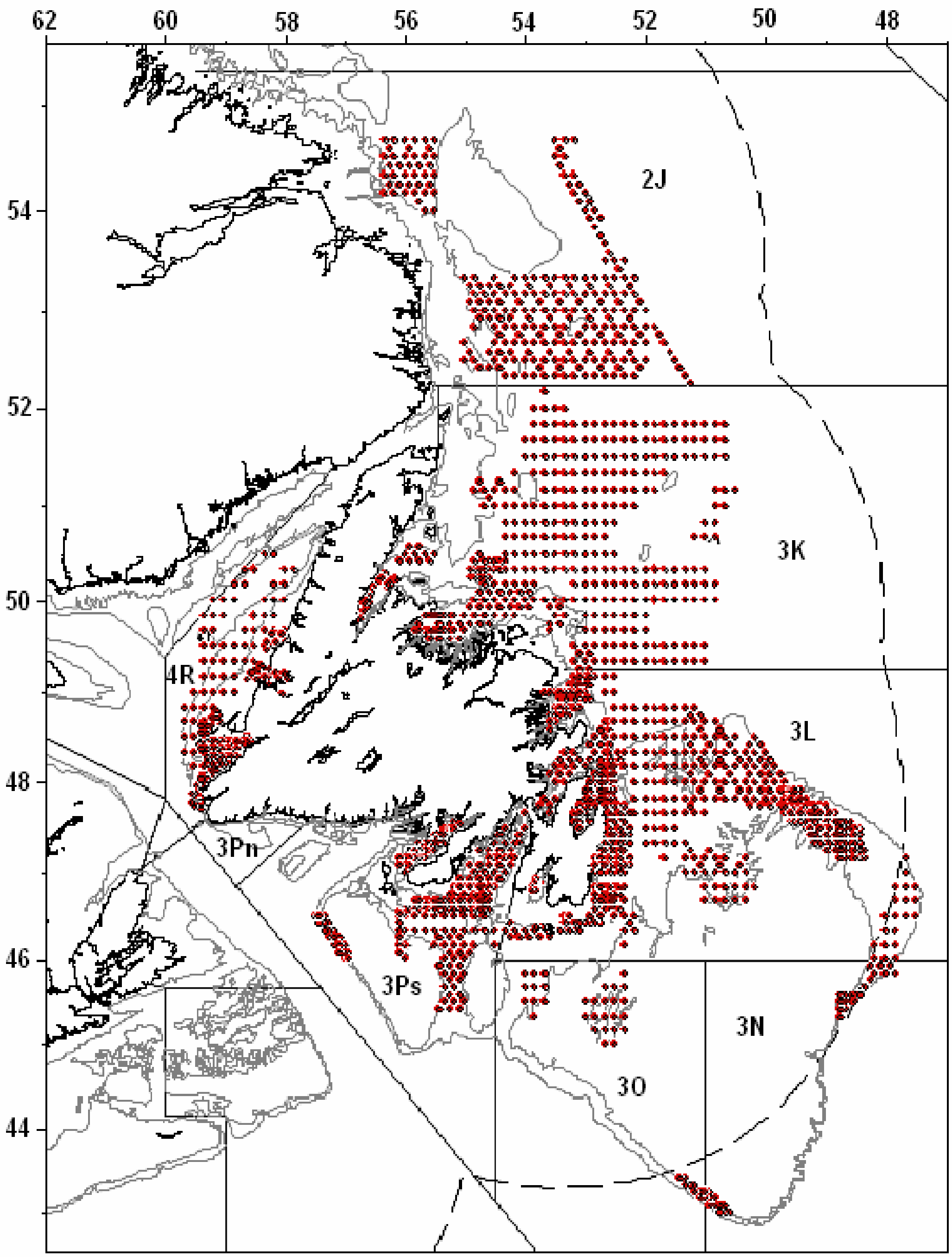


Figure 2. Industry-DFO collaborative post-season trap survey stations.

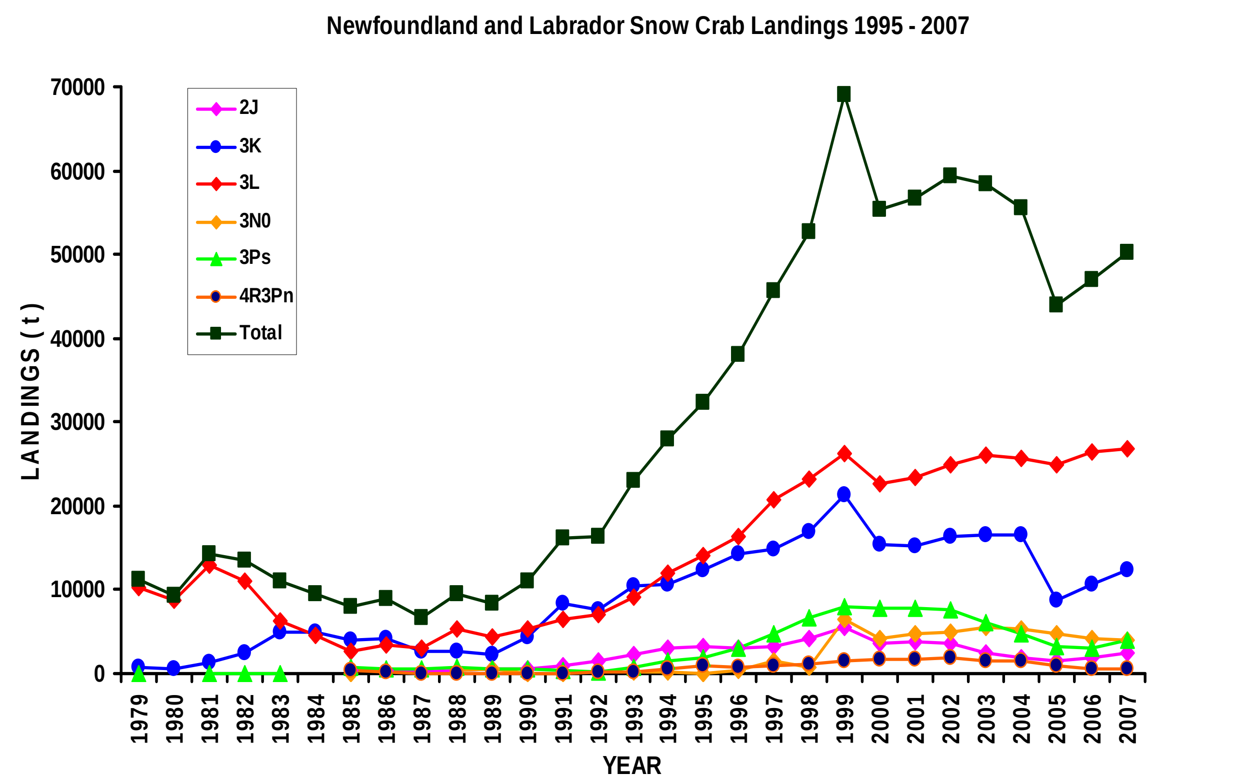


Figure 3. Trends in landings by NAFO Division and in total.

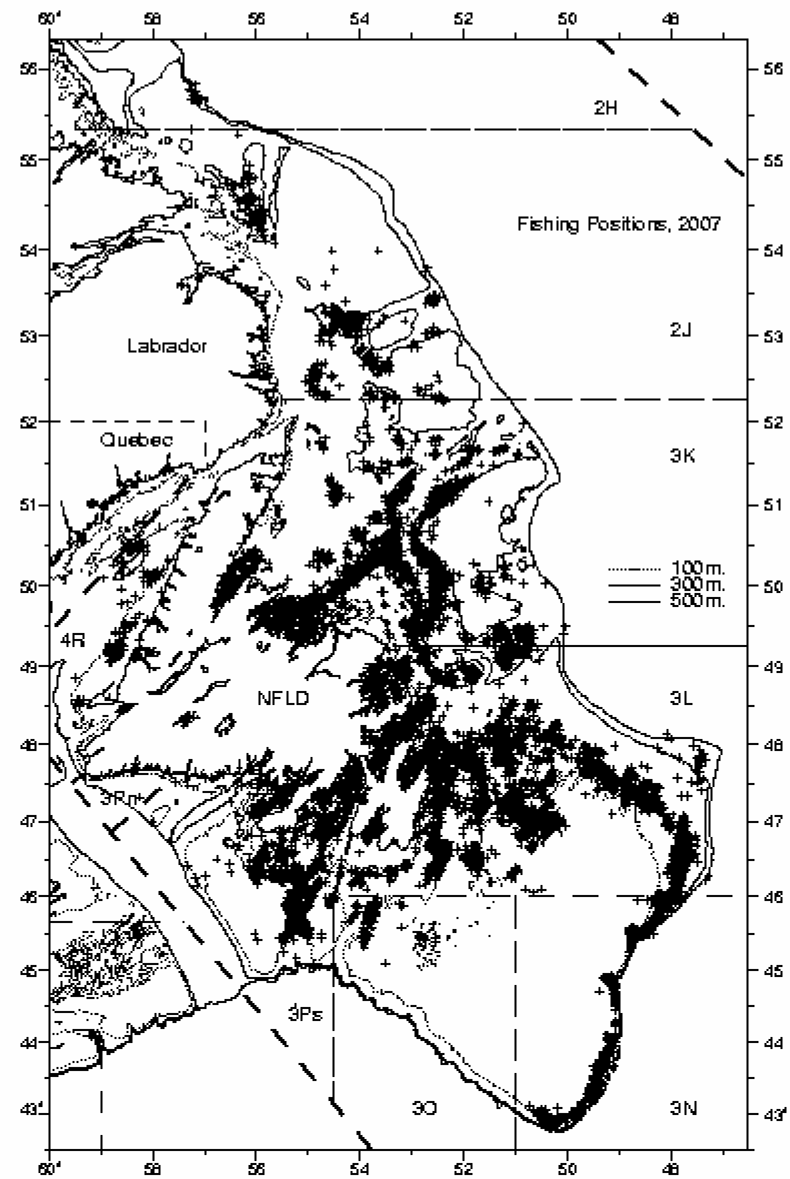


Figure 4. Spatial distribution of commercial fishing effort during 2007.

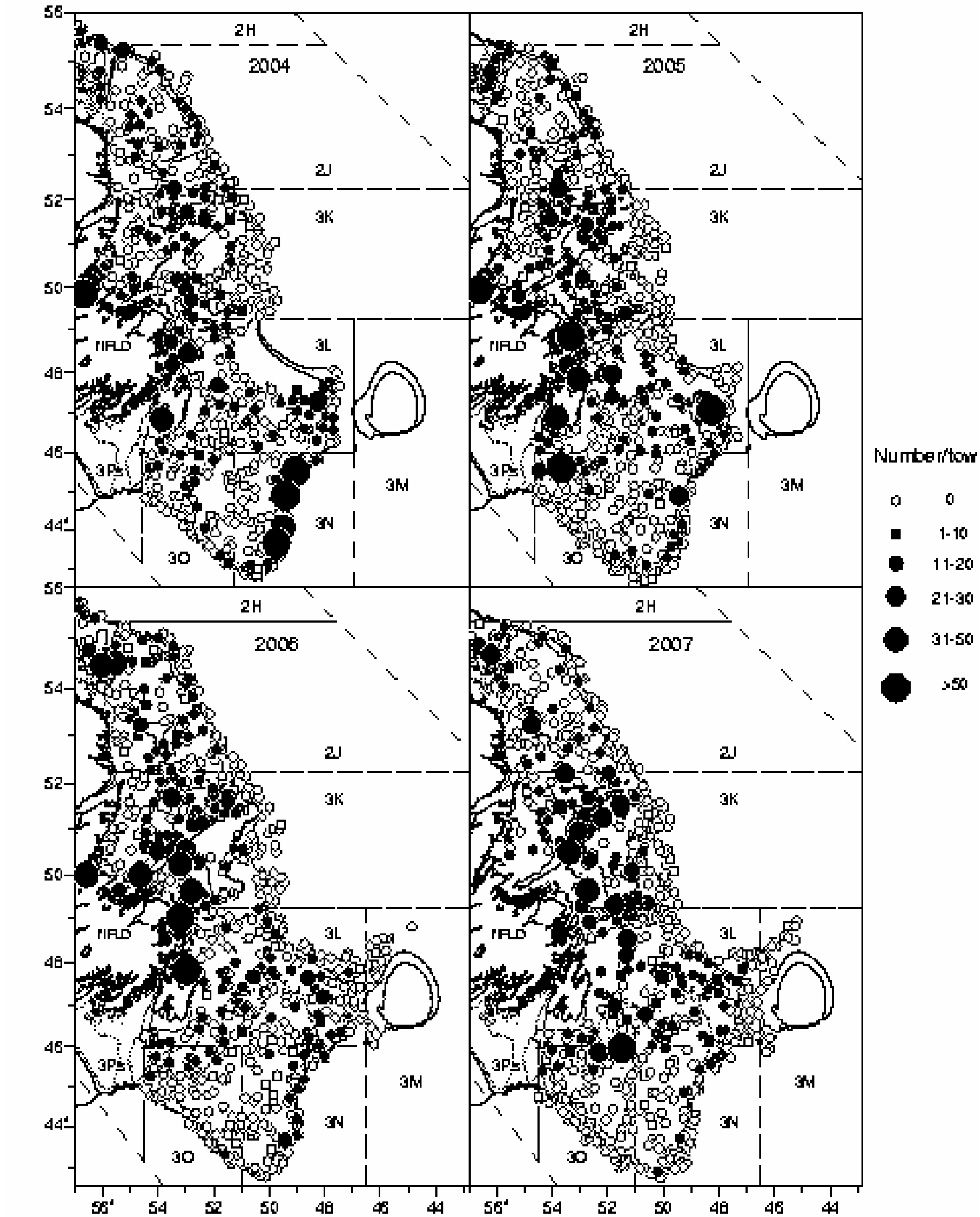


Figure 5. Distribution of exploitable males (> 94 mm CW adults) from fall Divisions 2J3KLNO bottom trawl surveys from 2004 to 2007.

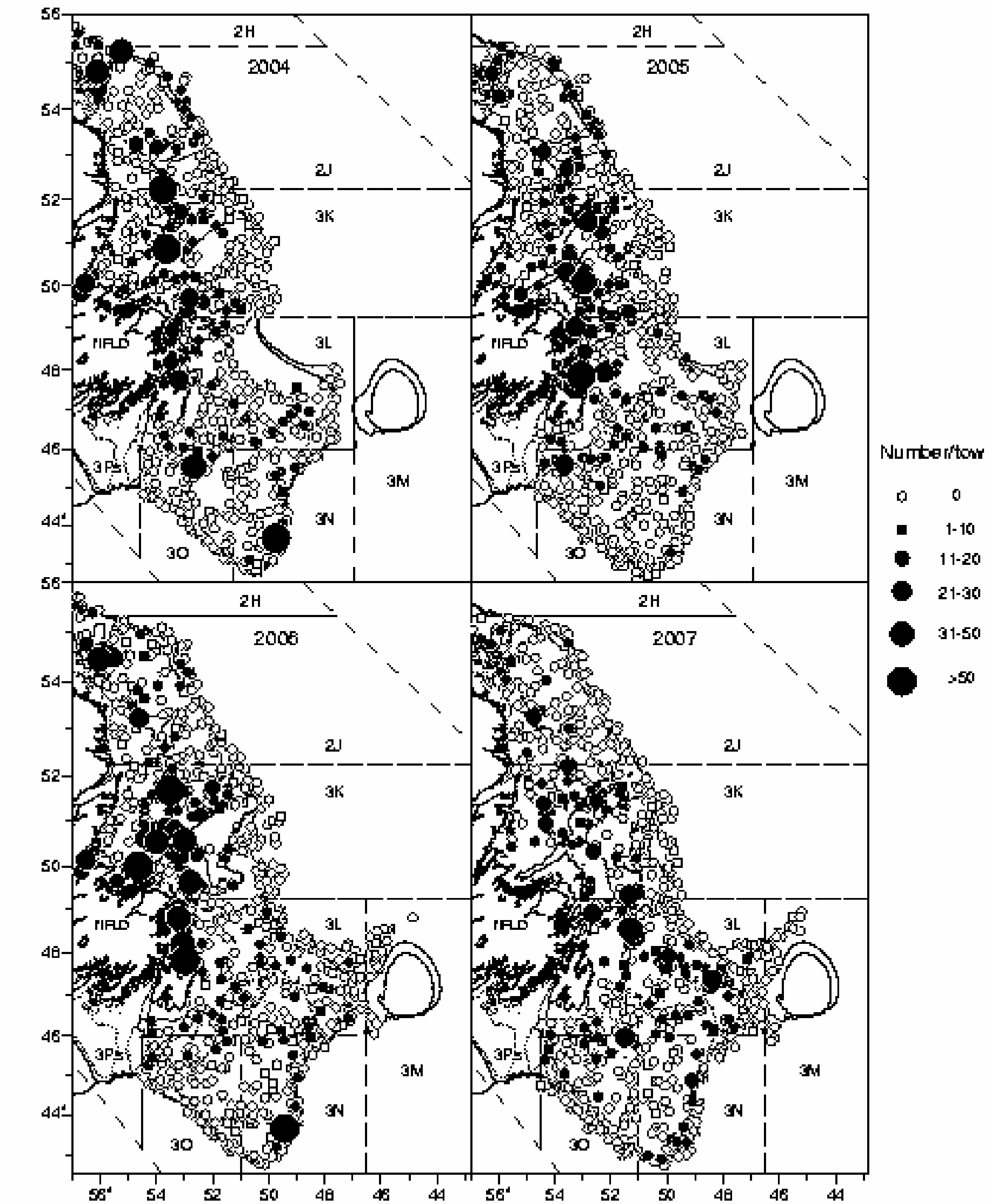


Figure 6. Distribution of pre-recruit males (>75 mm CW adolescents) from fall Division 2J3KLNO bottom trawl surveys from 2004 to 2007.

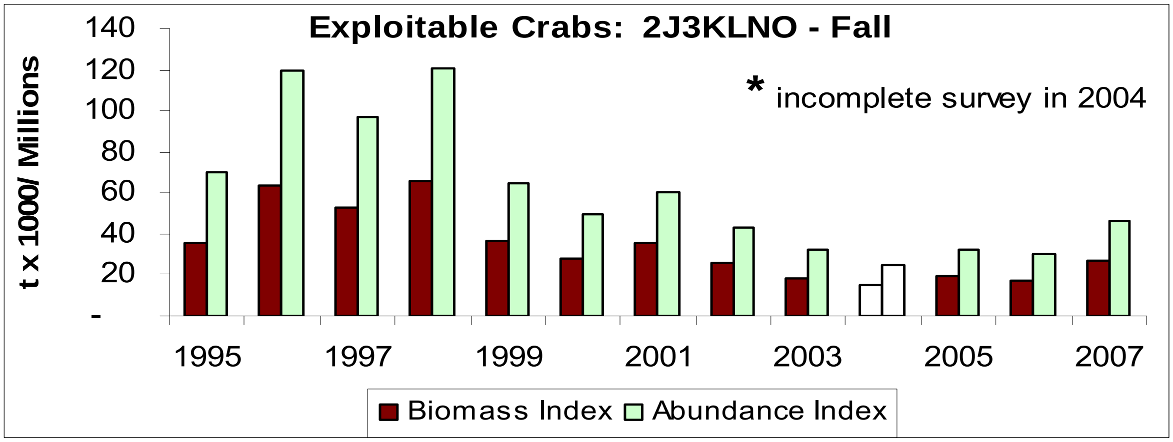


Figure 7. Trends in the fall trawl survey exploitable biomass and abundance indices, for Division 2J3KLNO.

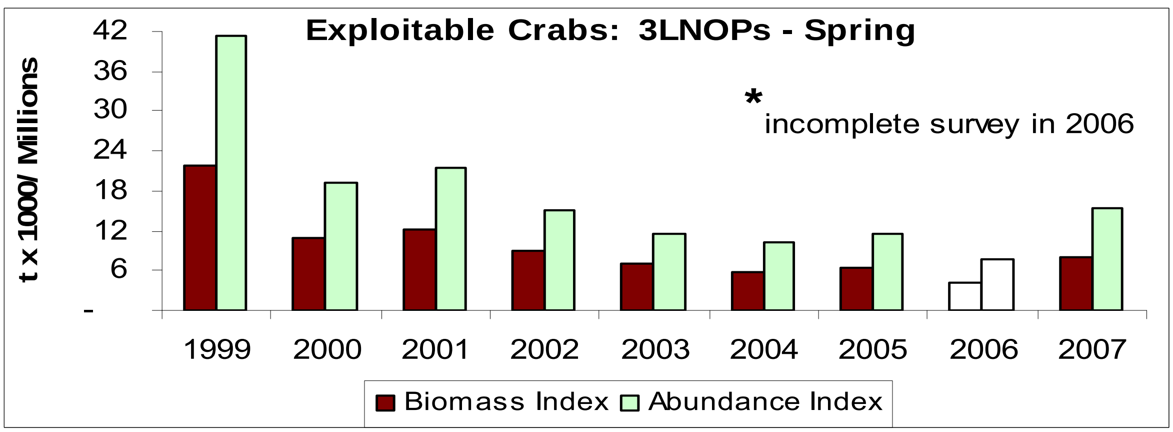


Figure 8. Trends in the spring trawl survey exploitable biomass and abundance indices, for Divisions 3LNOPs.

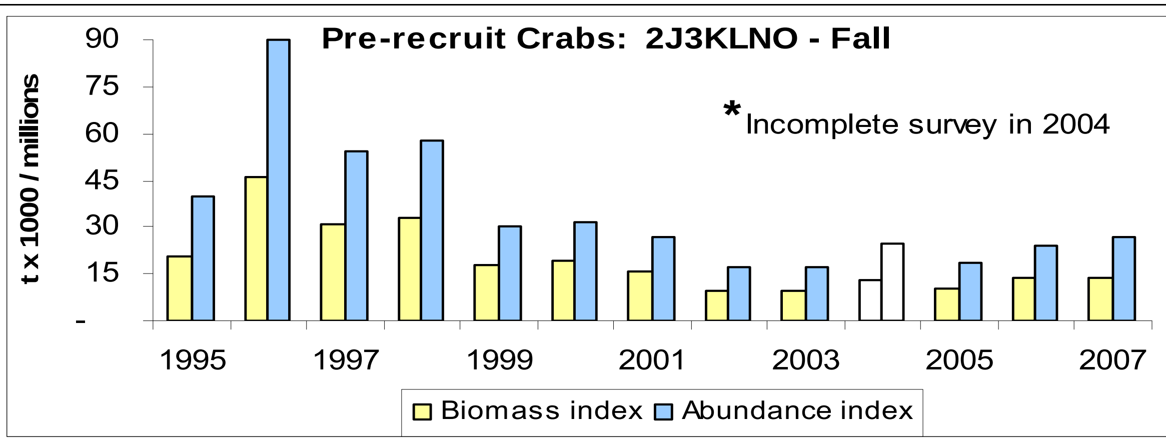


Figure 9. Trends in the fall trawl survey pre-recruit biomass and abundance indices, for Divisions 2J3KLNO.

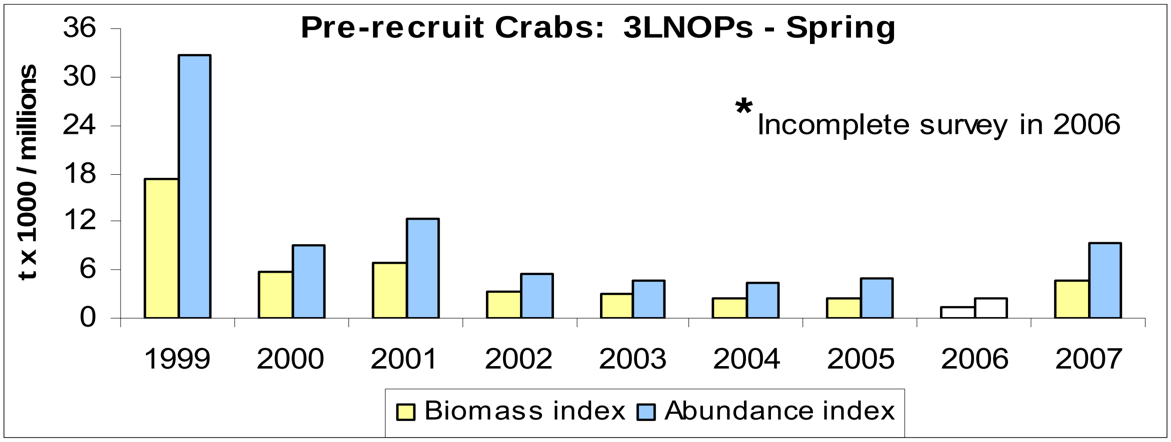


Figure 10 Trends in the spring trawl survey pre-recruit biomass and abundance indices, for Divisions 3LNOPs.

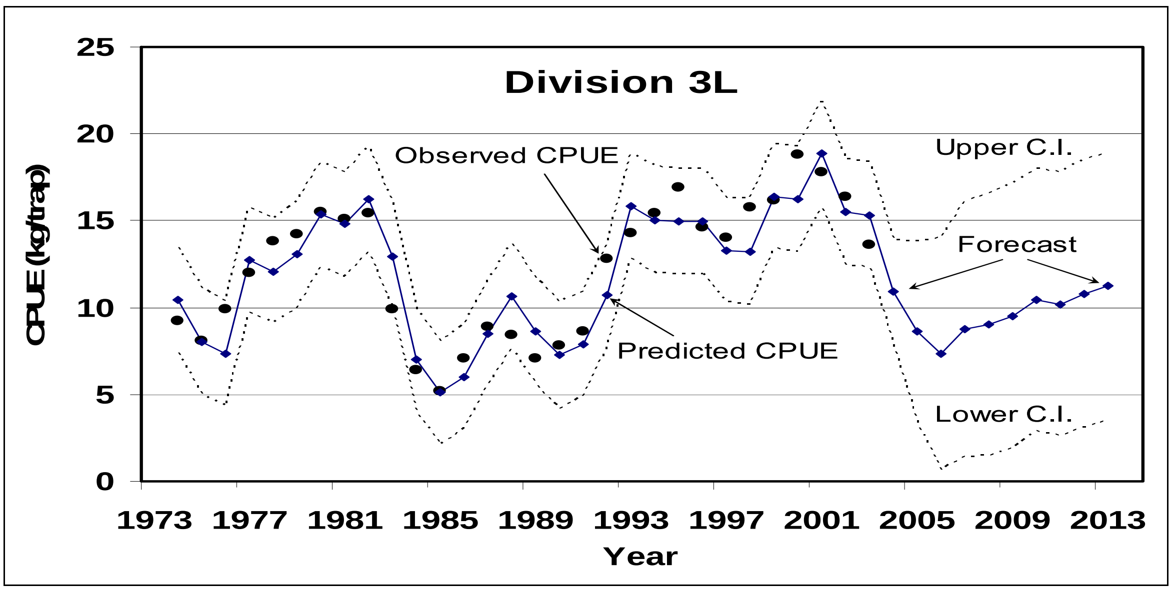


Figure 11. Comparison of observed Division 3L CPUE values with those predicted by a model that includes ice cover 10 years earlier as an explanatory variable.

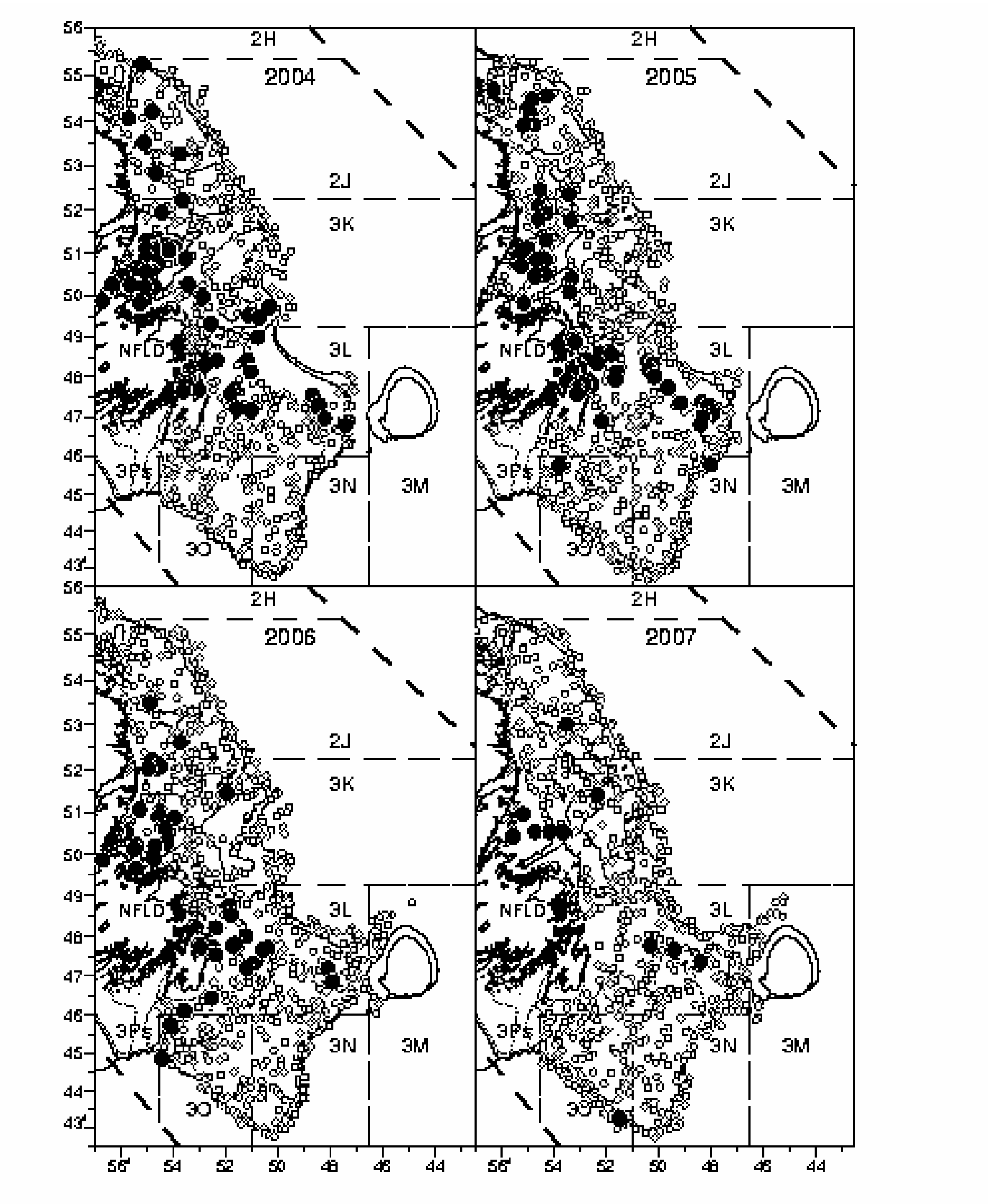


Figure 12. Distribution by year of fall trawl survey sets where BCD was encountered (closed circles) versus all other sets (open circles) from 2004 to 2007.

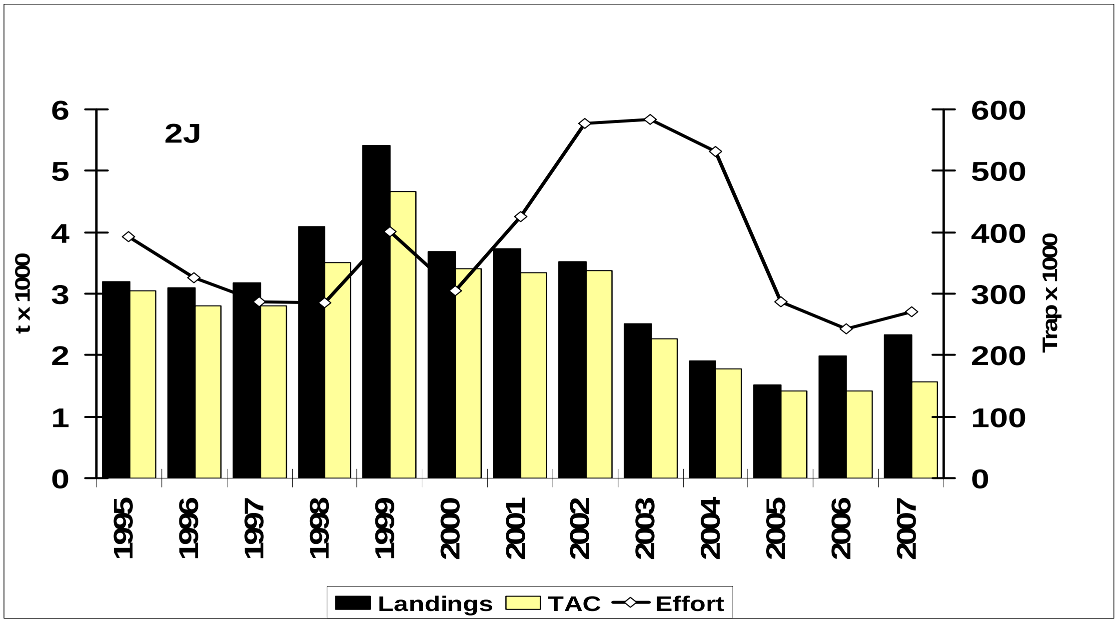


Figure 13. Trends in Division 2J landings, TAC, and fishing effort.

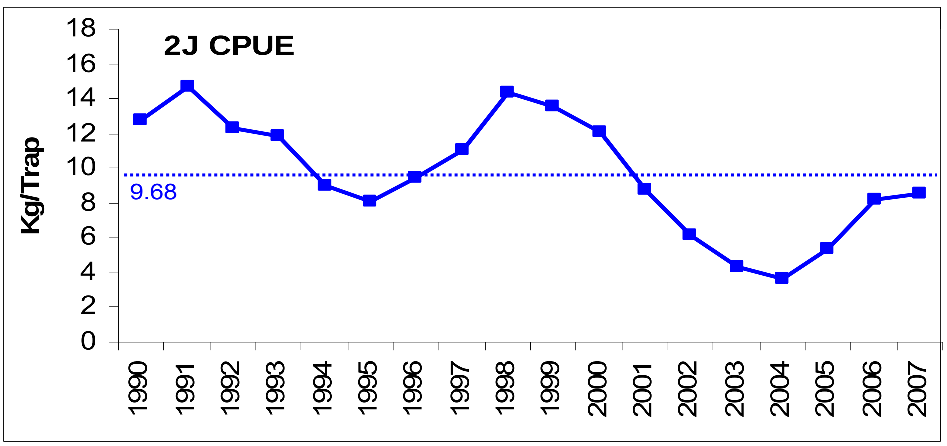


Figure 14. Trends in Division 2J commercial CPUE in relation to the long-term average (dotted line).

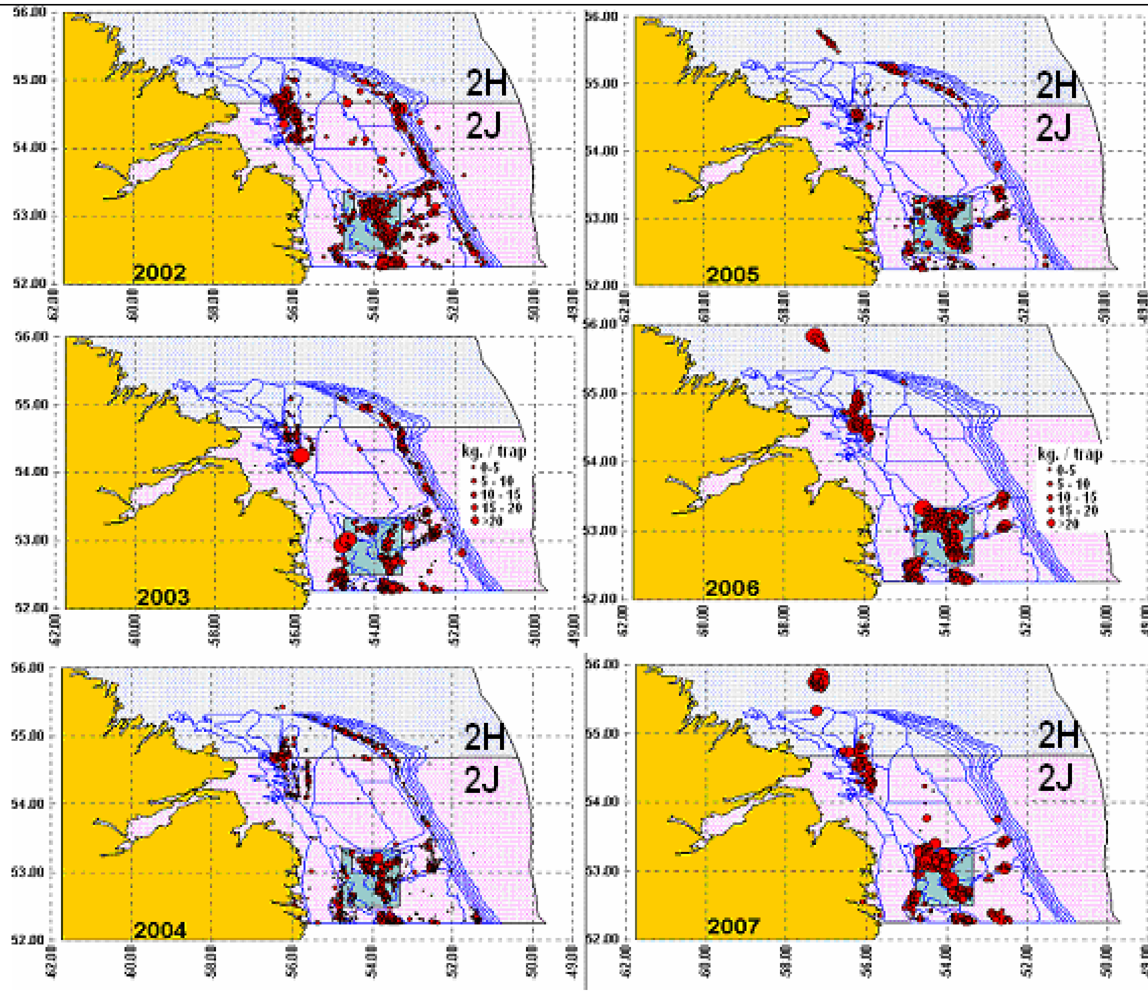


Figure 15. Spatial distribution of Division 2J commercial CPUE by year showing the Hawke channel closed area.

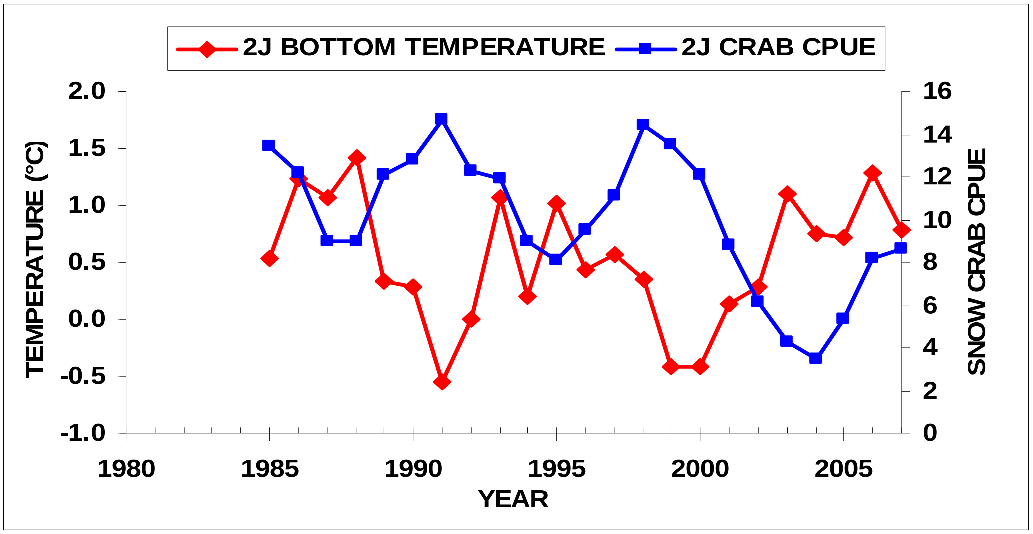


Figure 16. Trends in commercial CPUE in the Division 2J fishery vs. bottom temperature at a seven year lag.

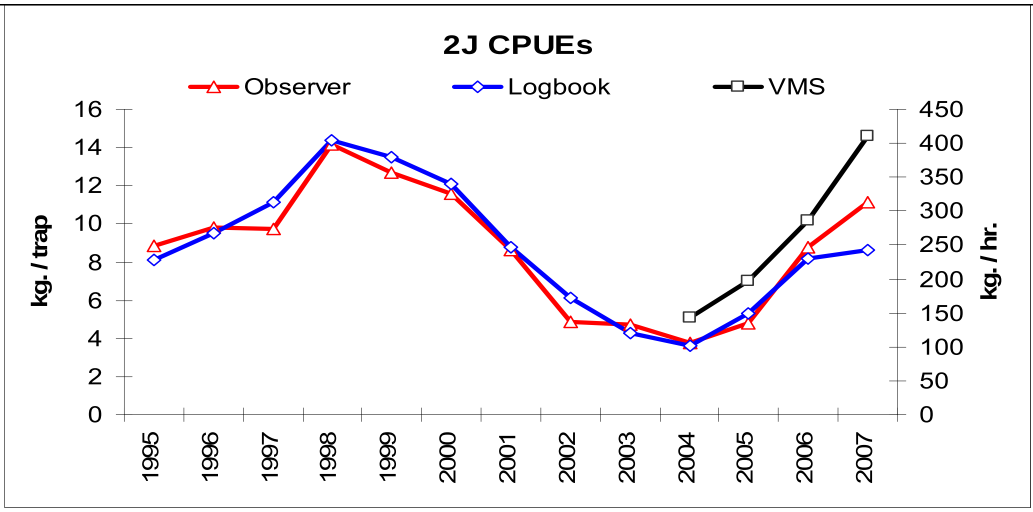


Figure 17. Trends in commercial logbook-based CPUE, observer-based CPUE and VMS-based CPUE in the Division 2J fishery.

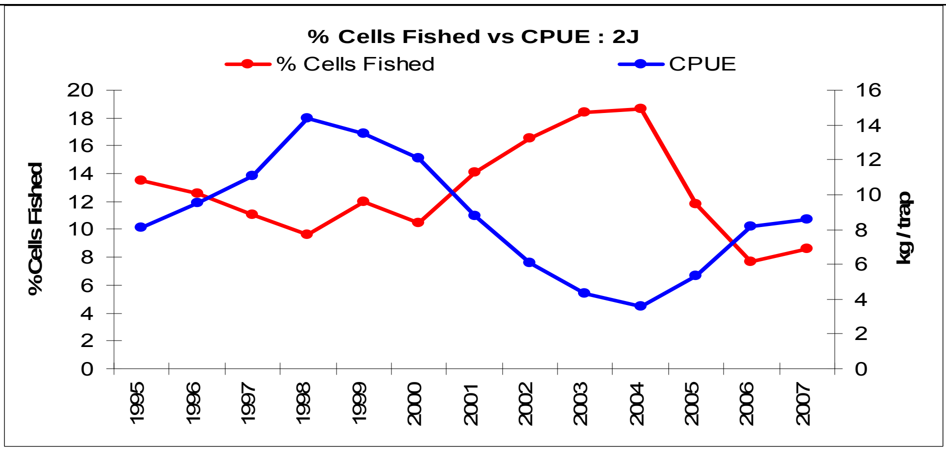


Figure 18. Trends in Division 2J commercial CPUE vs. the percentage of 5’ x 5’ cells fished.

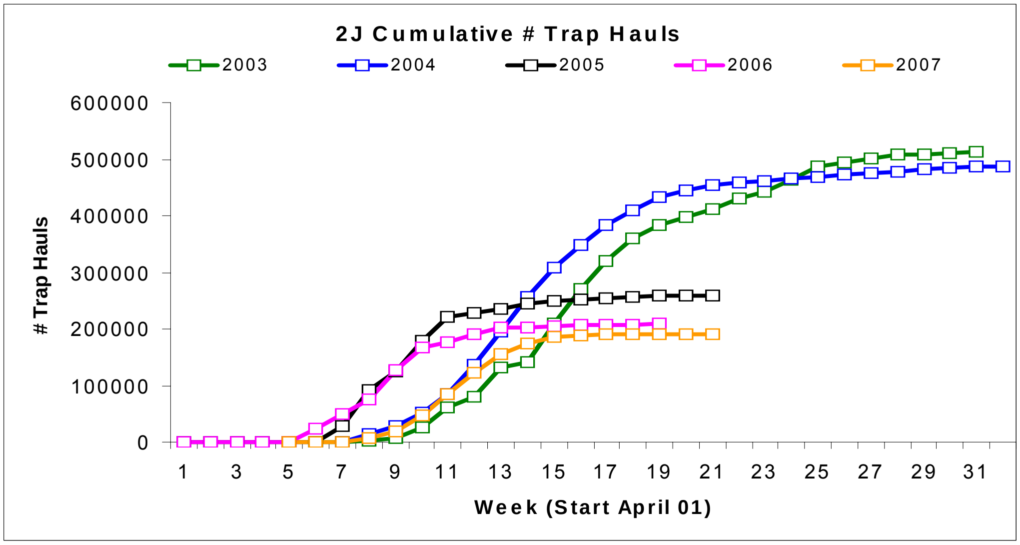


Figure 19. Seasonal trends in fishing effort for Division 2J during 2003-07.

a)

b)

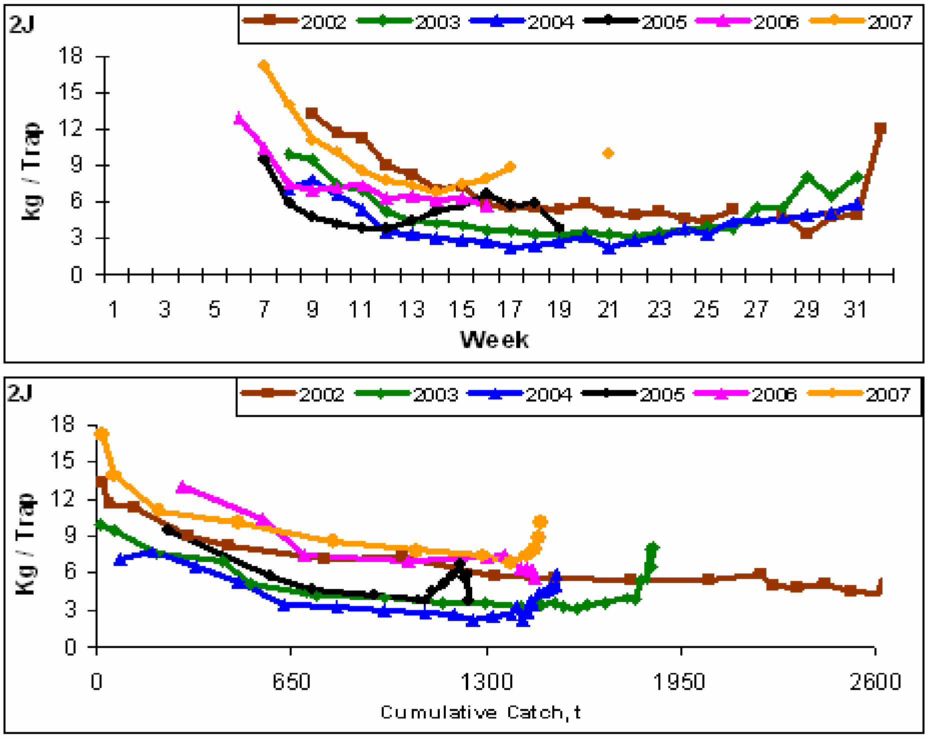


Figure 20 Seasonal trends in logbook-based CPUE for Division 2J during 2002-07; (a) by week, and (b) in relation to cumulative catch.

a)

b)

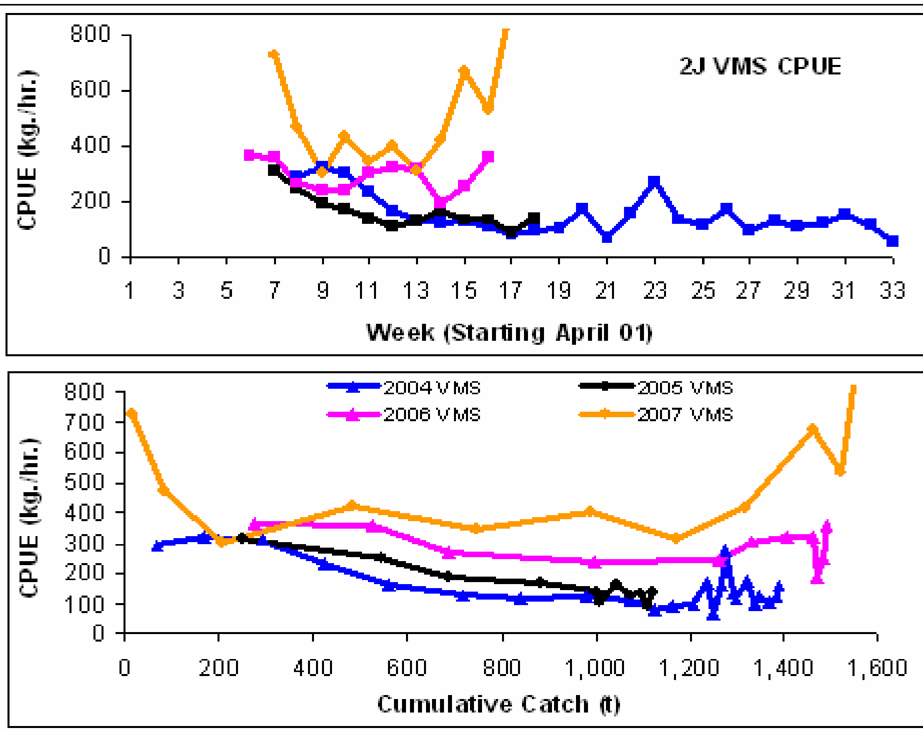


Figure 21. Seasonal trends in VMS-based CPUE for Division 2J during 2002-07; (a) by week, and (b) in relation to cumulative catch.

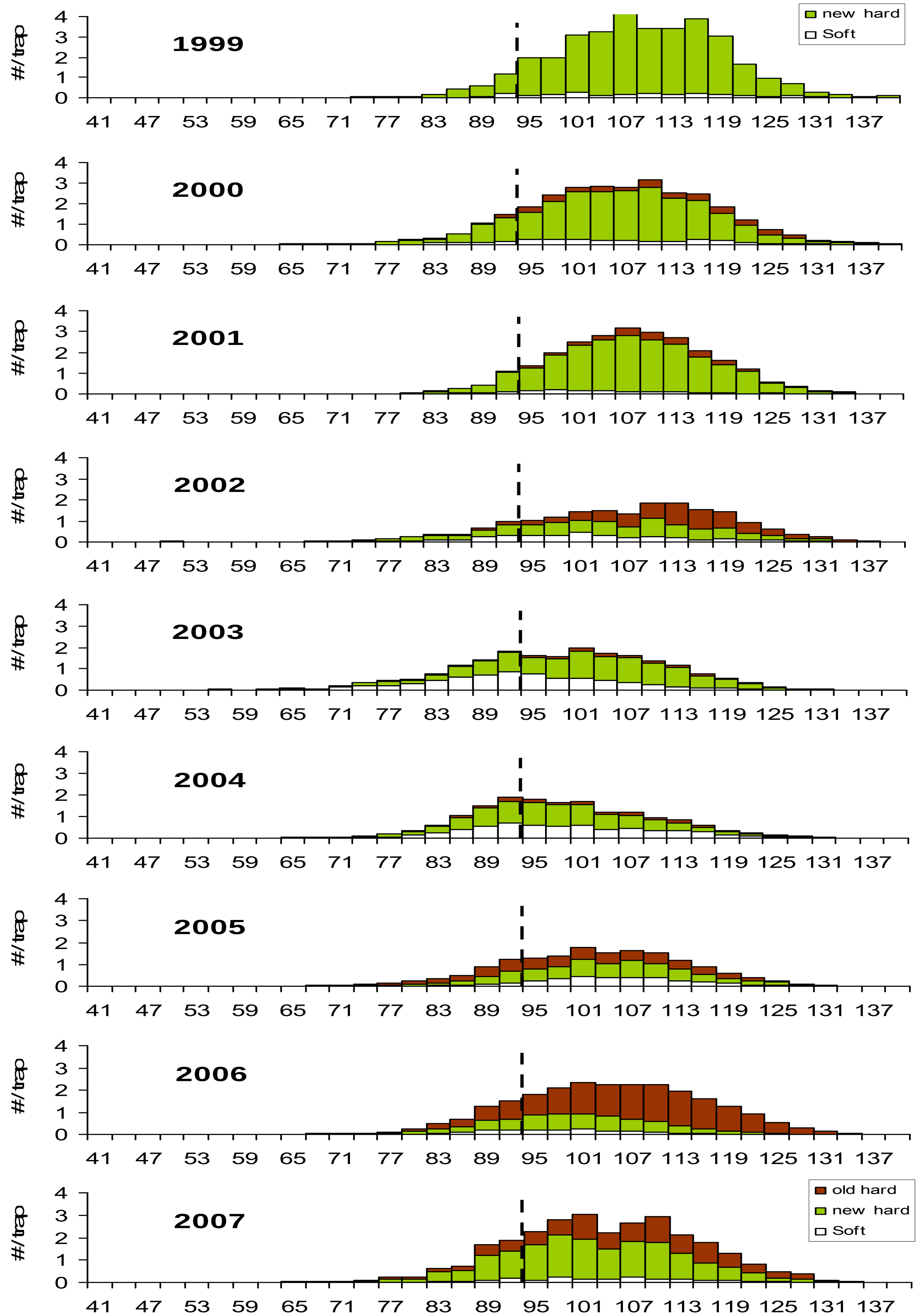
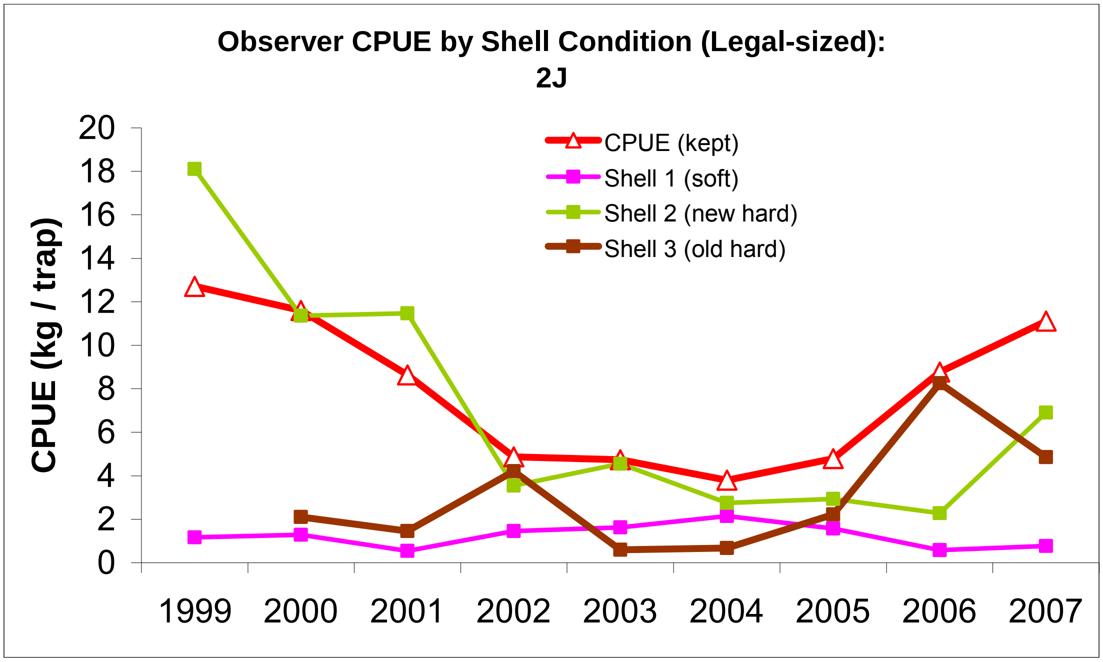


Figure 22. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Division 2J. The vertical dashed line indicates the minimum legal size.

a)



b)

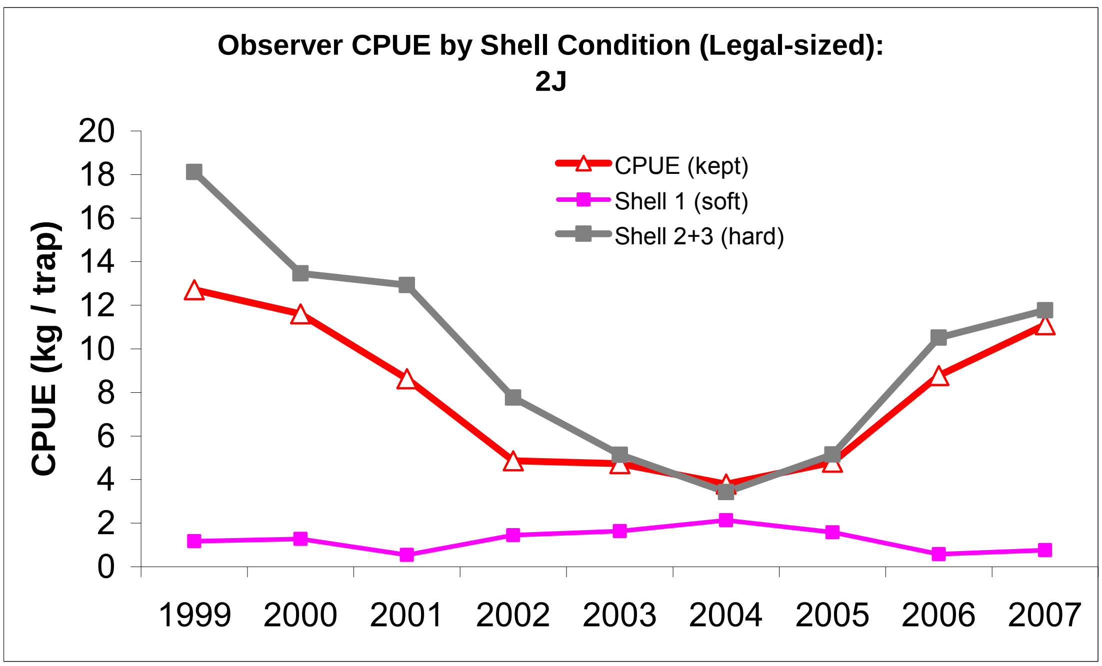


Figure 23. Trends in Division 2J observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

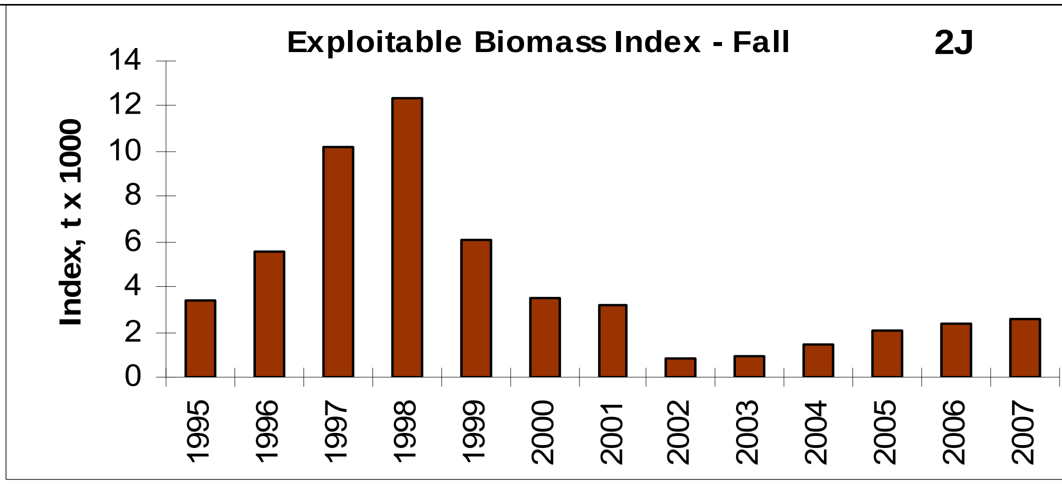


Figure 24. Trends in the Division 2J fall trawl survey exploitable biomass index.

a)

b)

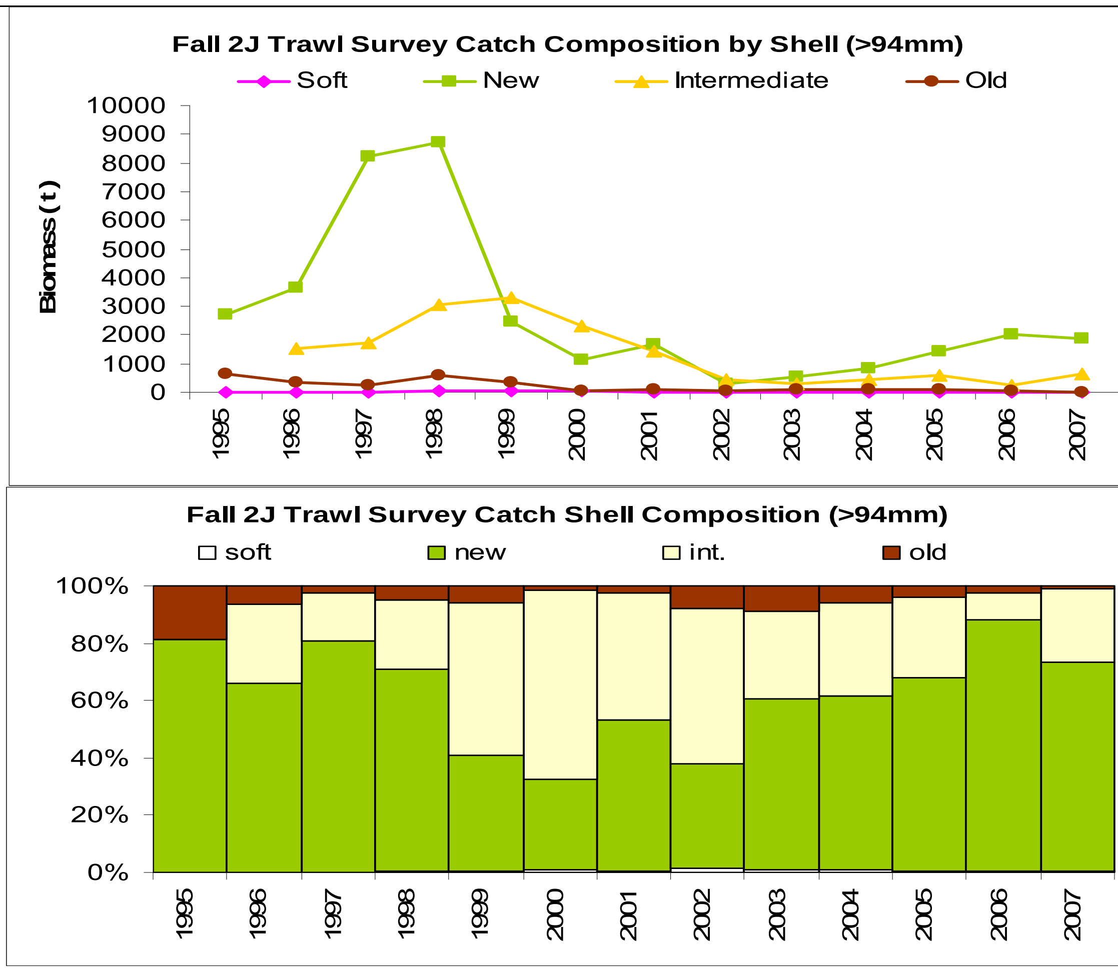


Figure 25. Trends, by shell condition, in legal-sized males for Division 2J from fall trawl surveys for; a) biomass, and (b) percentages of the total catch.

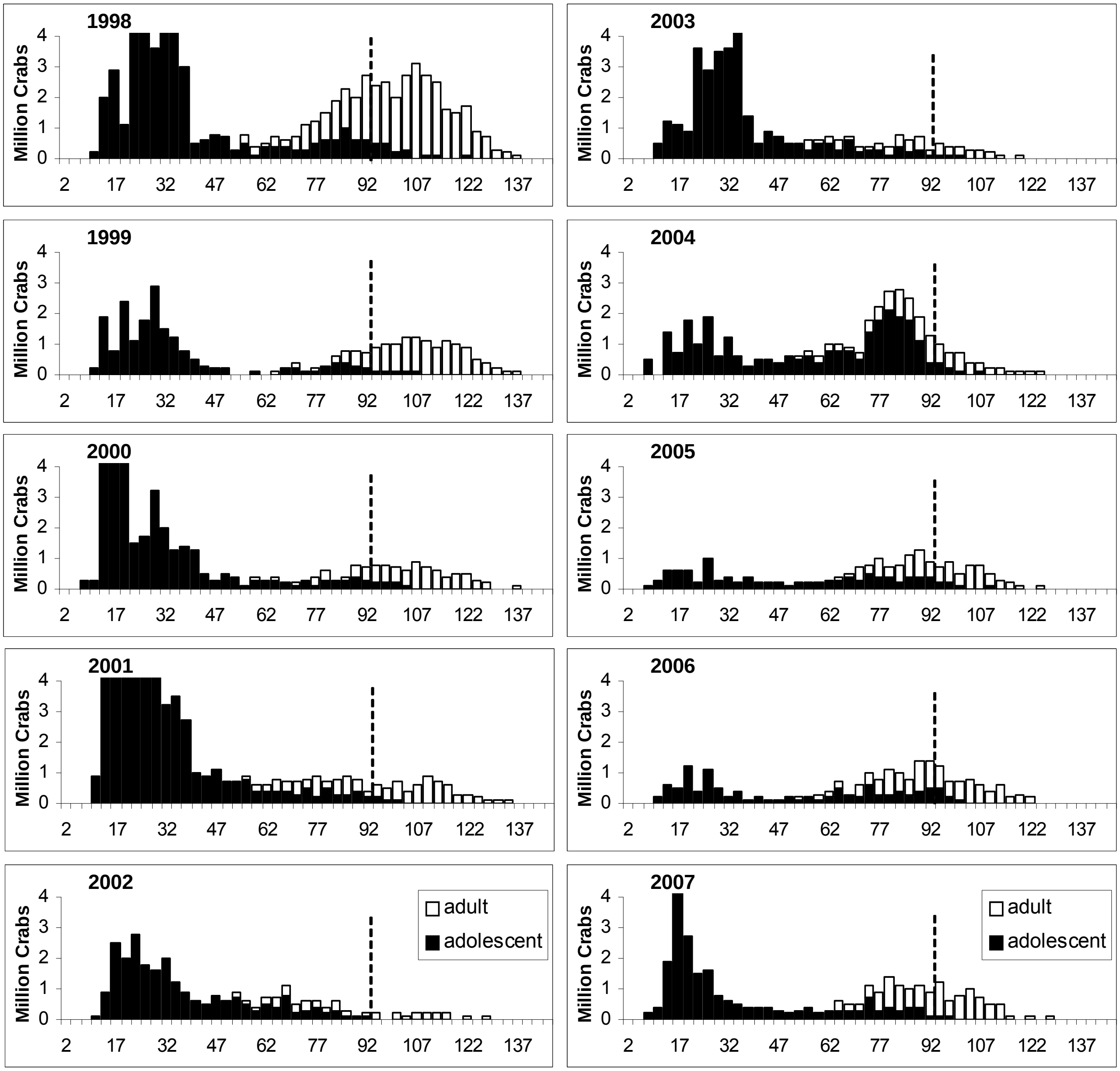


Figure 26. Distribution of abundance (index) by carapace width for Division 2J juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50 mm Cw). The minimum legal size is indicated by a vertical dashed line.

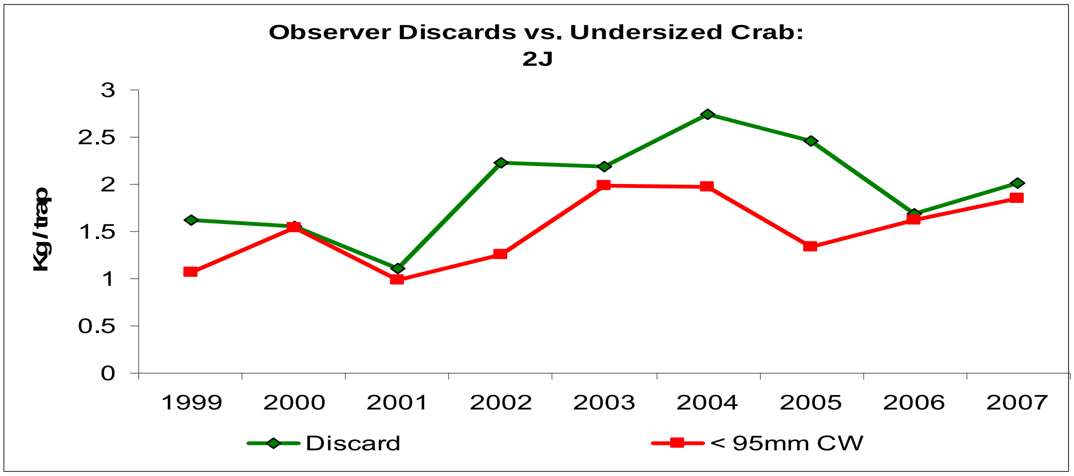


Figure 27. Trends in Division 2J observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

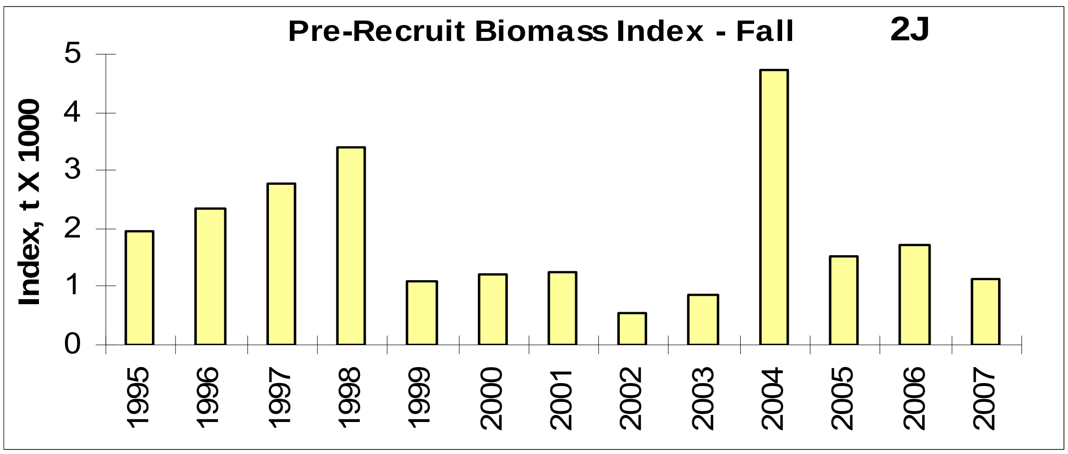


Figure 28. Trends in the Division 2J fall trawl survey pre-recruit biomass index.

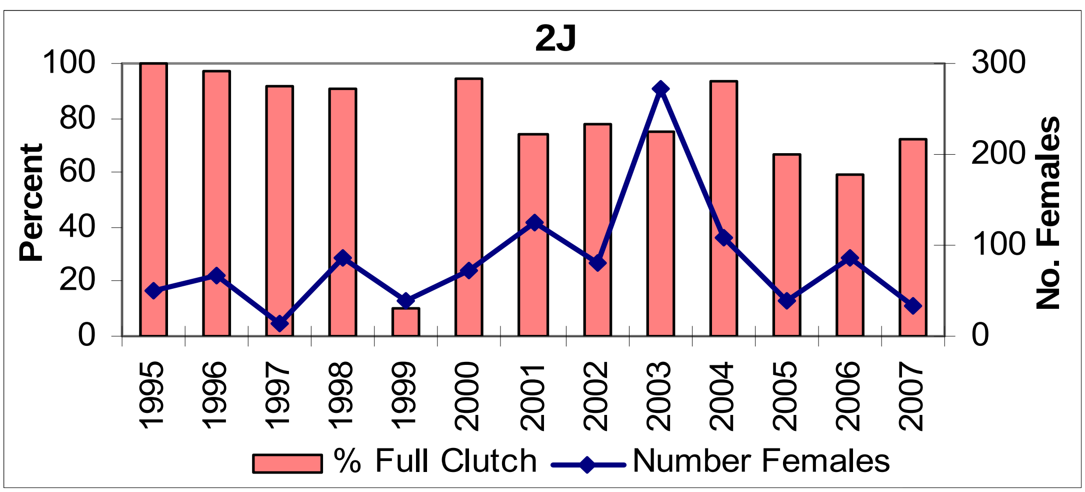


Figure 29. Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 2J from fall multi-species surveys.

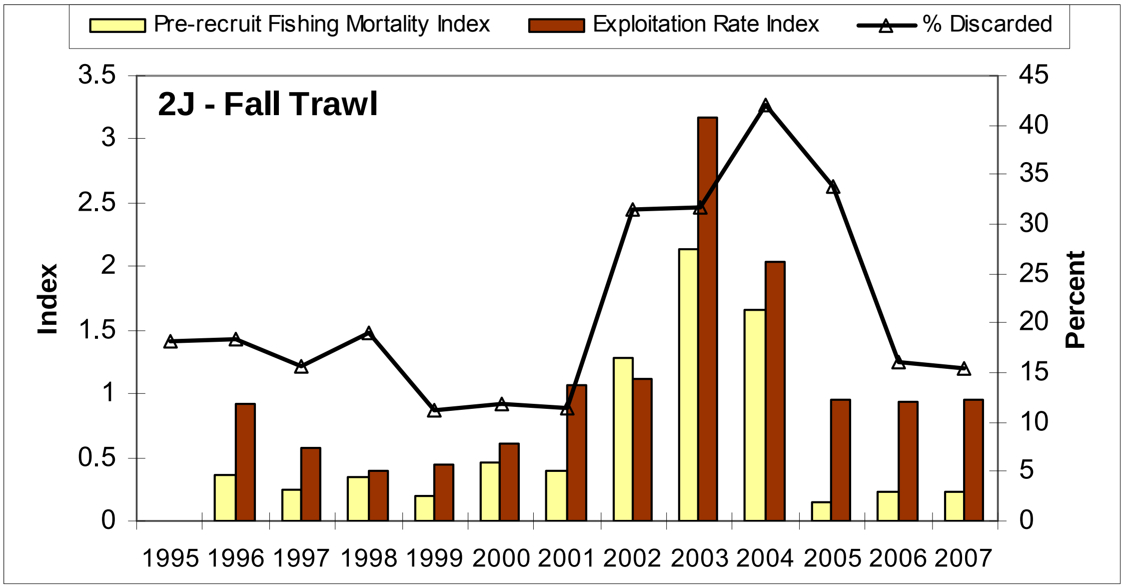


Figure 30. Trends in Division 2J mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery.

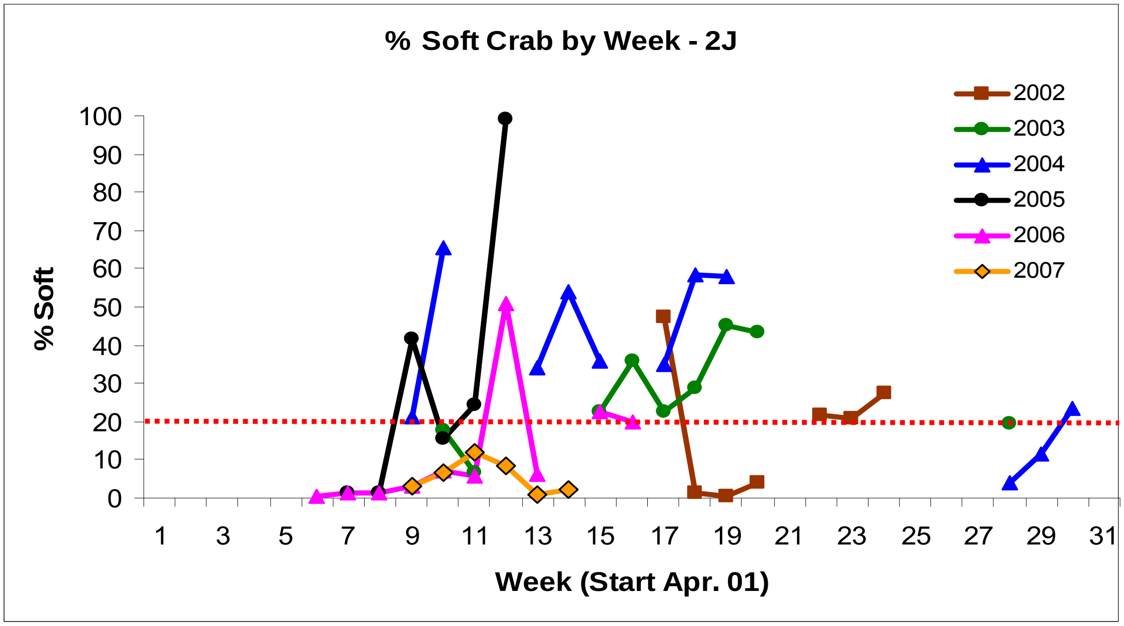


Figure 31. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Division 2J fishery that are soft-shelled, by year (2002-07), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed.)

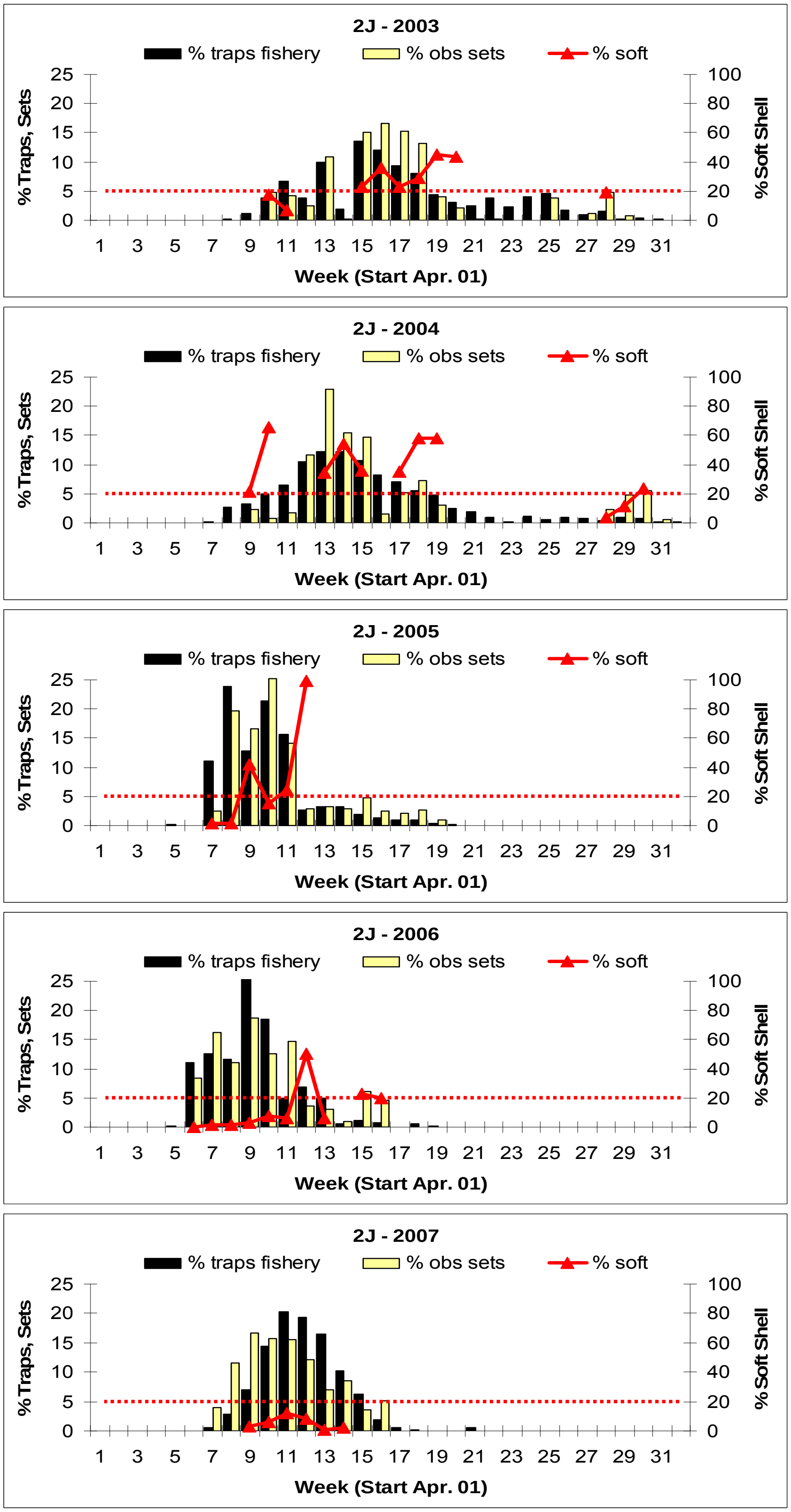


Figure 32. Seasonal trends in Division 2J distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2003-07. (Sample sizes of <10 observed sets/week removed.)

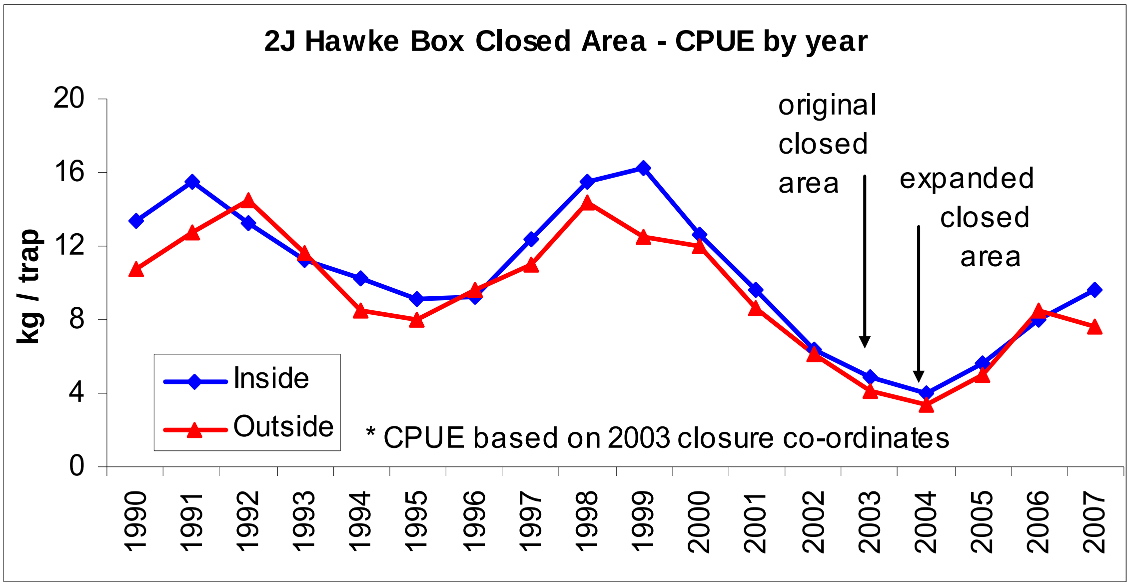


Figure 33. Division 2J commercial CPUE; inside vs. outside the Hawke Channel closed area.

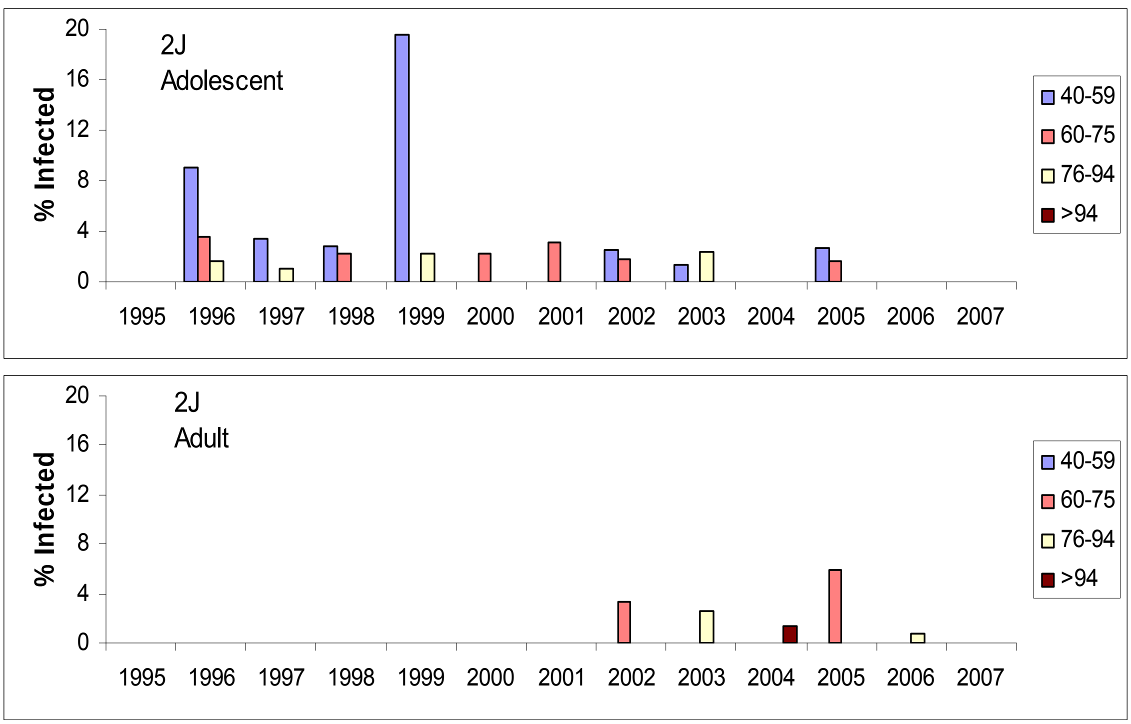
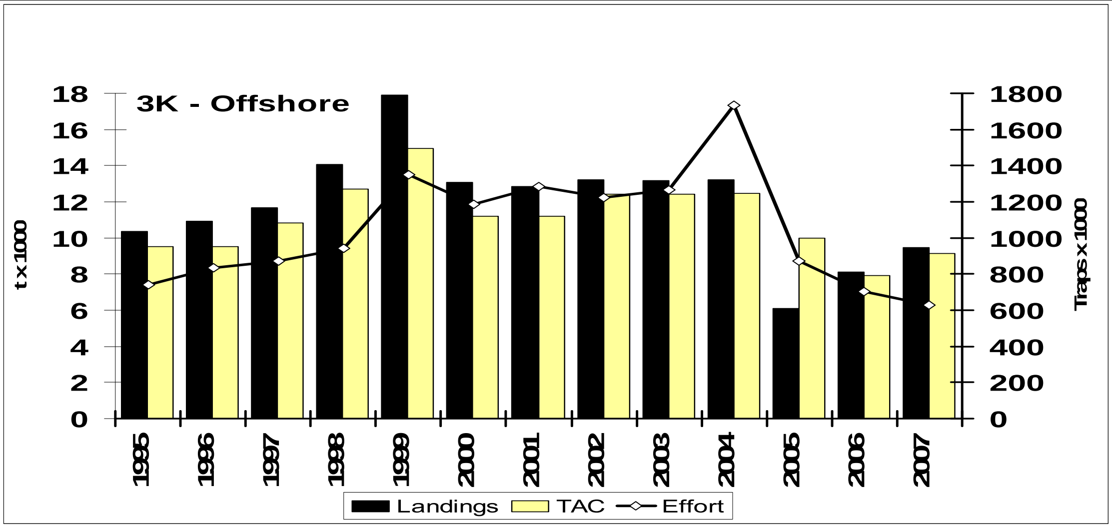


Figure 34. Trends in prevalence of BCD in new-shelled adolescents (above) and adults (below) by male size group from Division 2J fall trawl surveys.



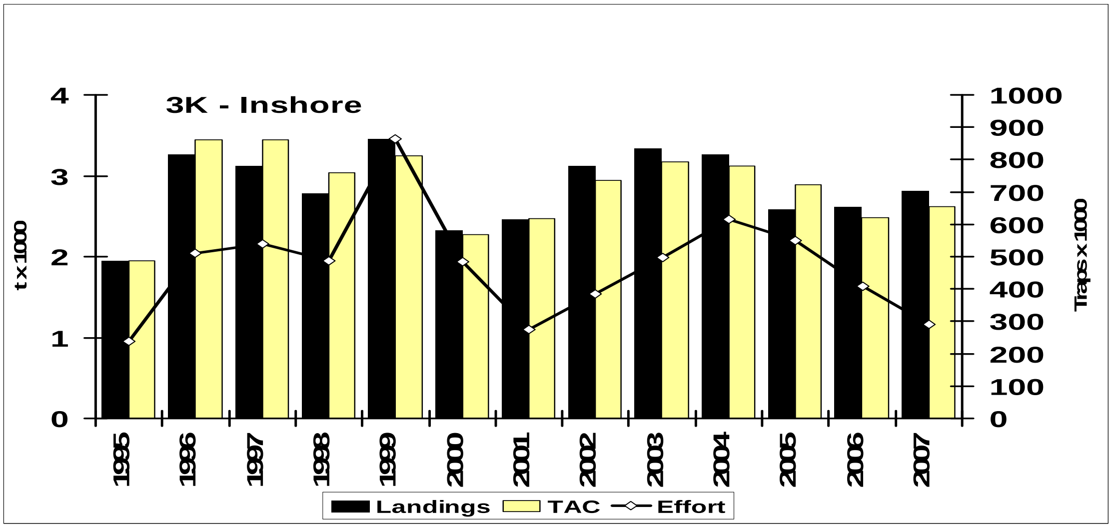


Figure 35. Trends in Division 3K landings, TAC, and fishing effort for the offshore (above) and inshore (below).

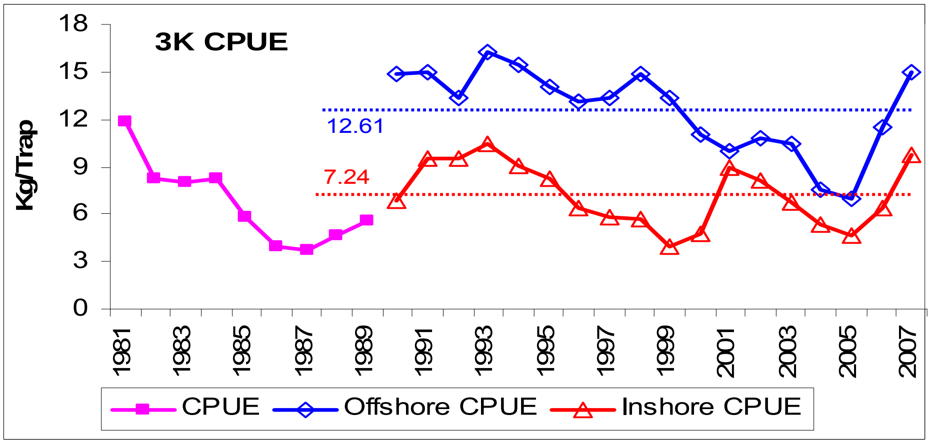


Figure 36.Trends in Division 3K offshore and inshore commercial CPUE in relation to their long-term averages (dotted lines).

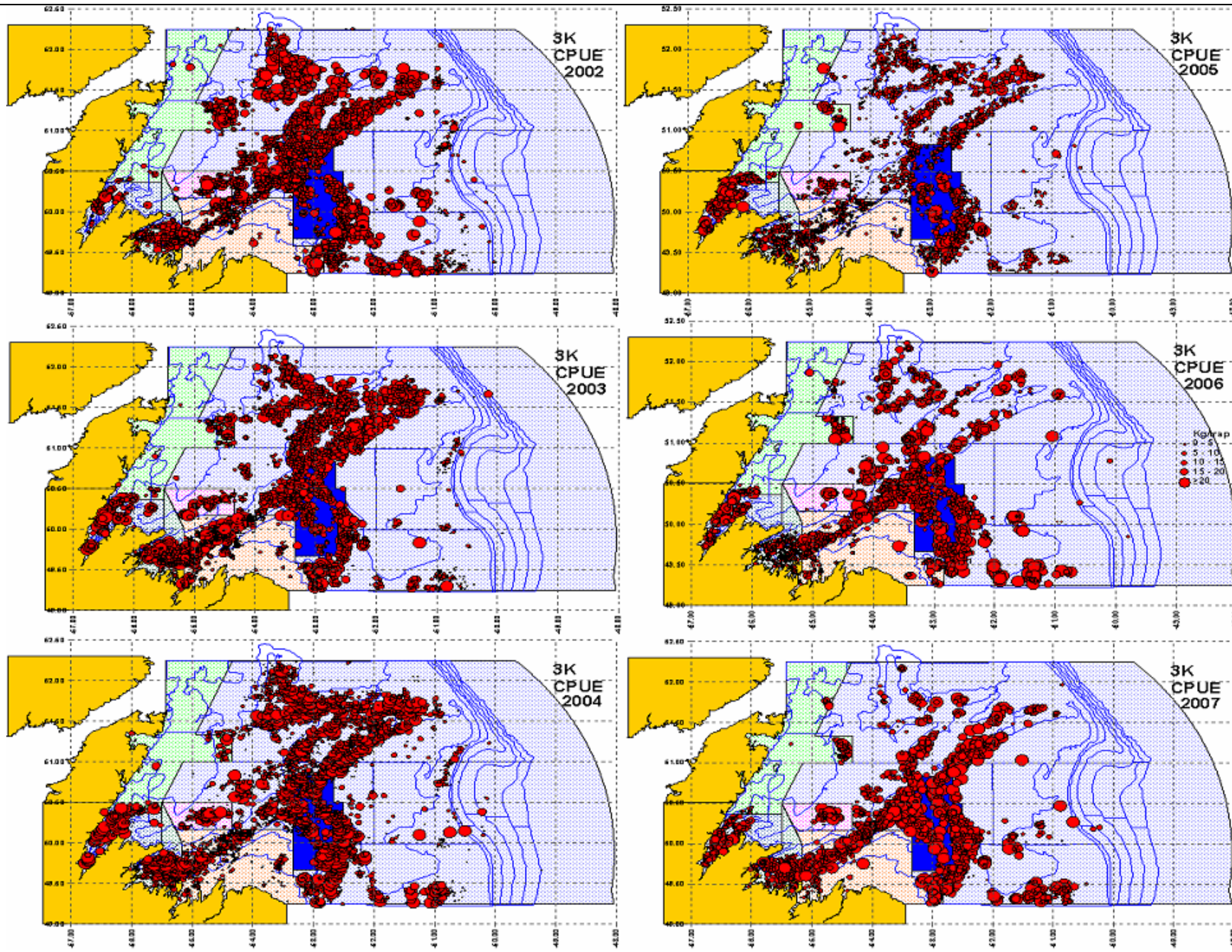


Figure 37.Spatial distribution of Division 3K commercial CPUE by year showing the Funk Island Deep closed area.

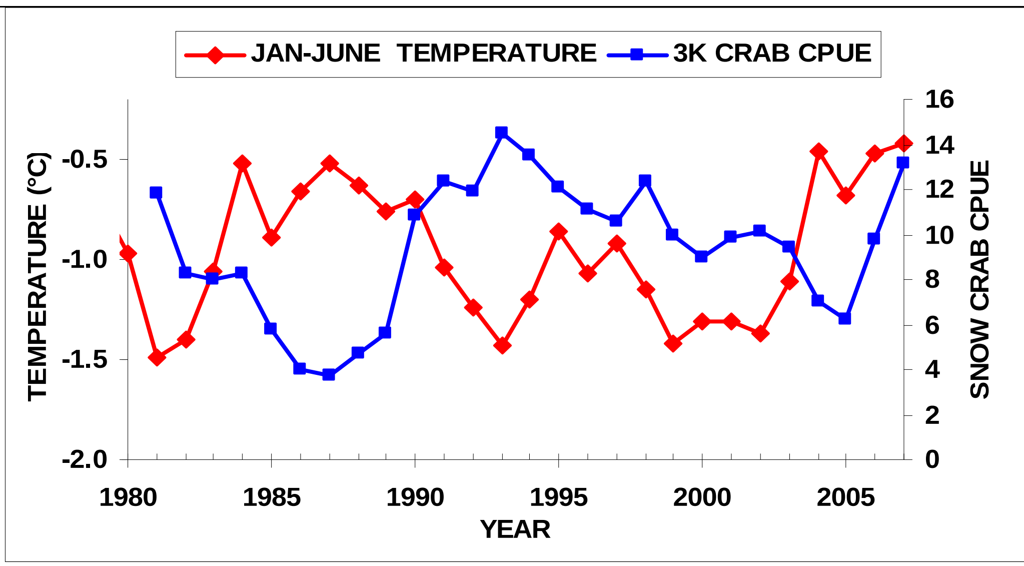


Figure 38. Trends in commercial CPUE in the Division 3K fishery (offshore and inshore combined) vs. bottom temperature at an eight year lag.

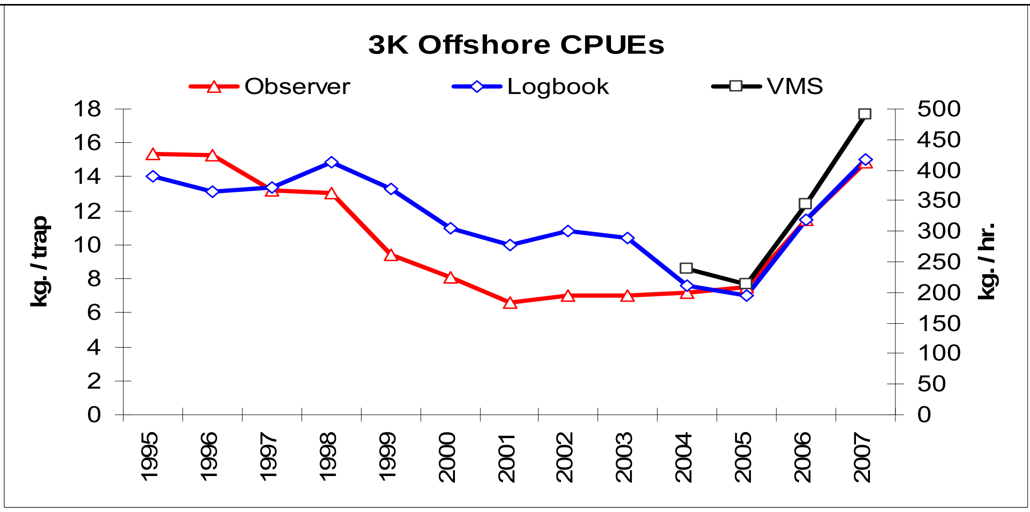


Figure 39. rends in commercial logbook-based CPUE, observer-based CPUE and VMS-based CPUE in the Division 3K offshore fishery.

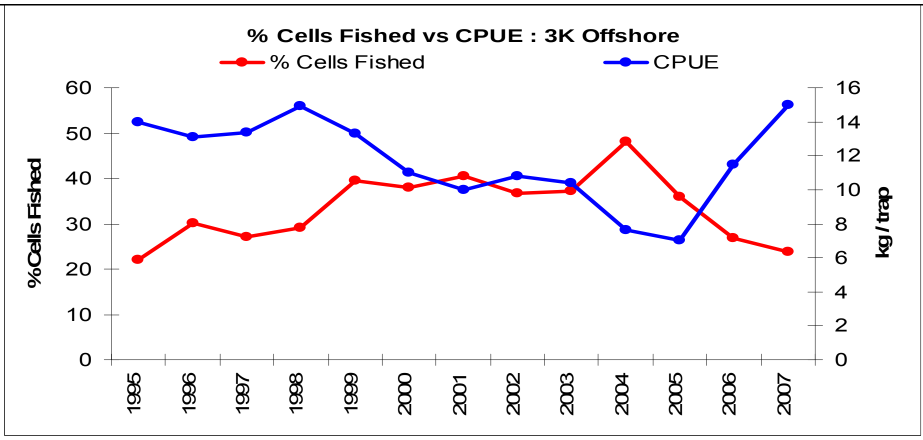


Figure 40.Trends in Division 3K offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

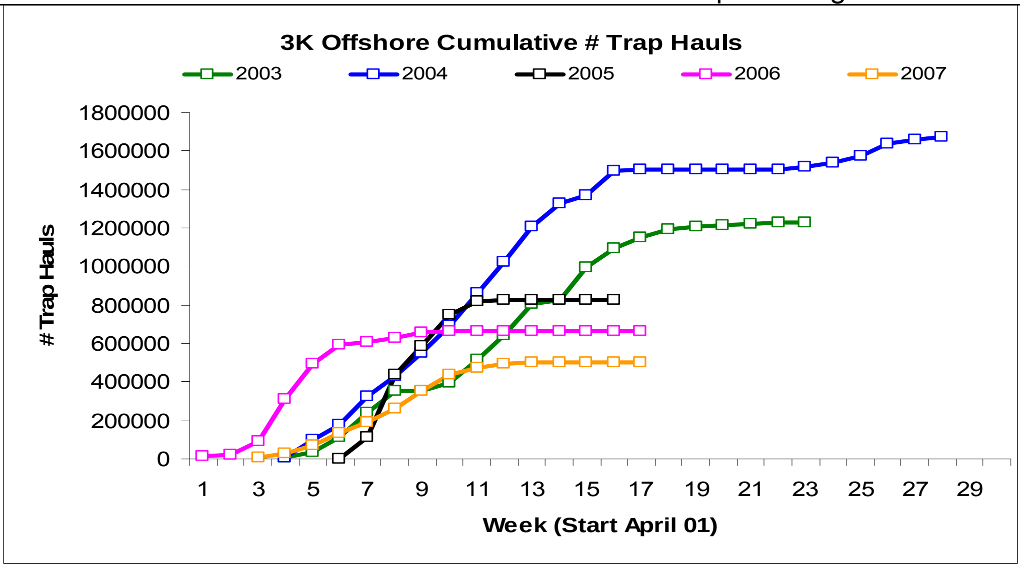


Figure 41. Seasonal trends in fishing effort for Division 3K offshore during 2003-07.

a)

b)

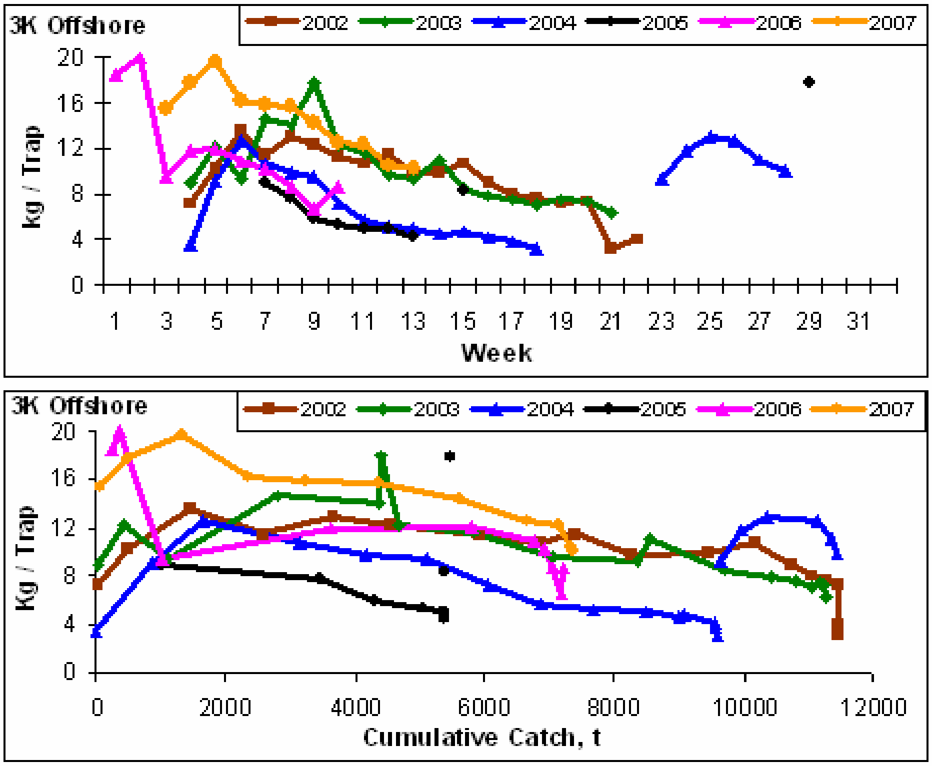


Figure 42. Seasonal trends in logbook-based CPUE for Division 3K offshore during 2002-07; (a) by week, and (b) in relation to cumulative catch.

a)

b)

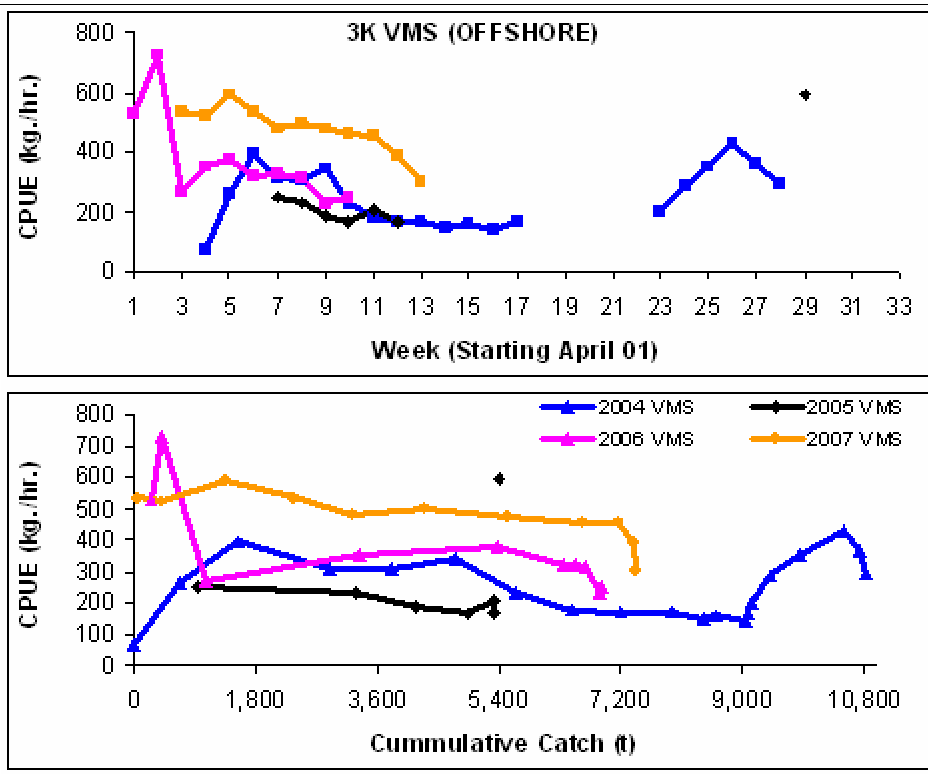


Figure 43. Seasonal trends in VMS-based CPUE for Division 3K offshore during 2002-07; (a) by week, and (b) in relation to cumulative catch.

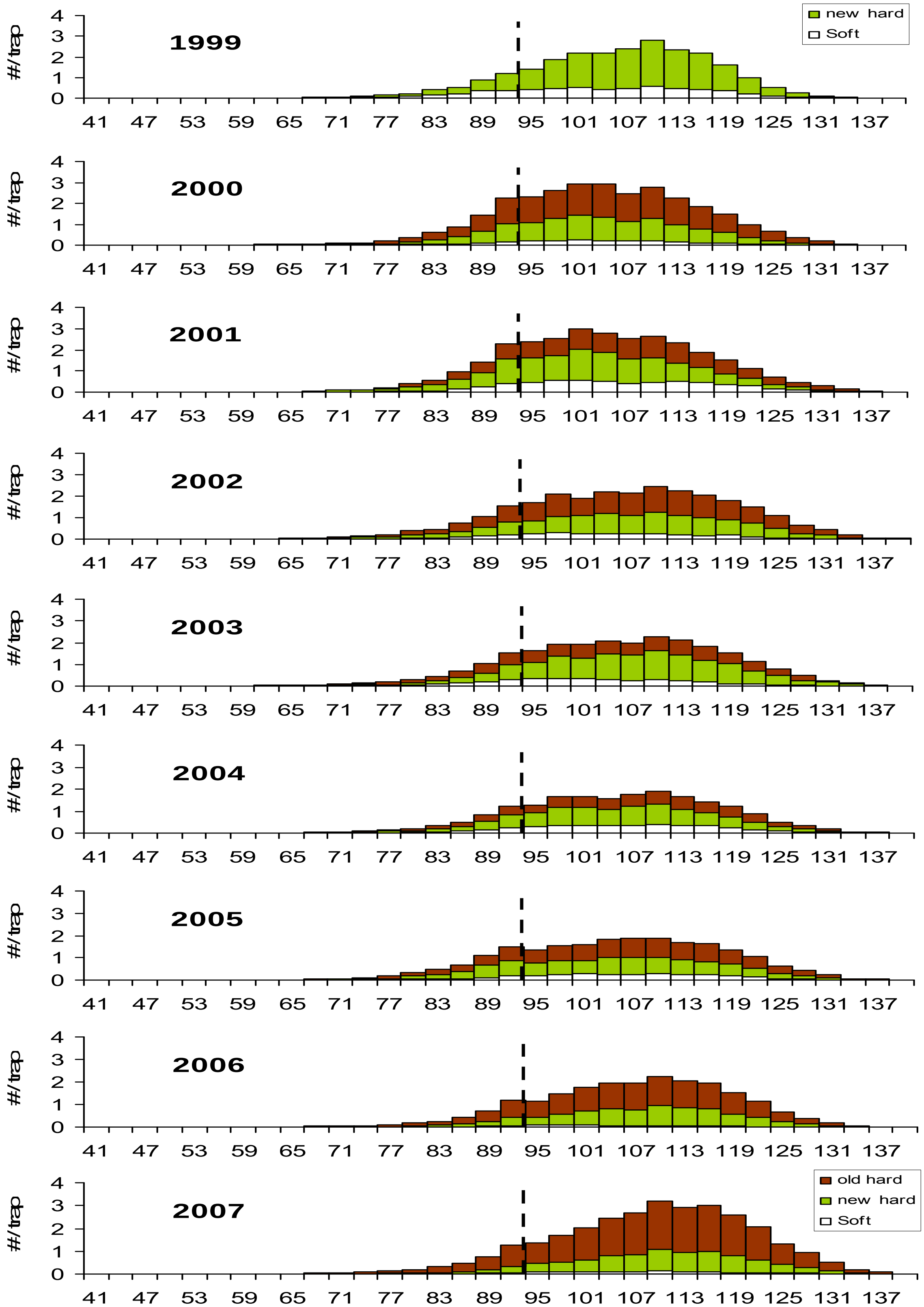
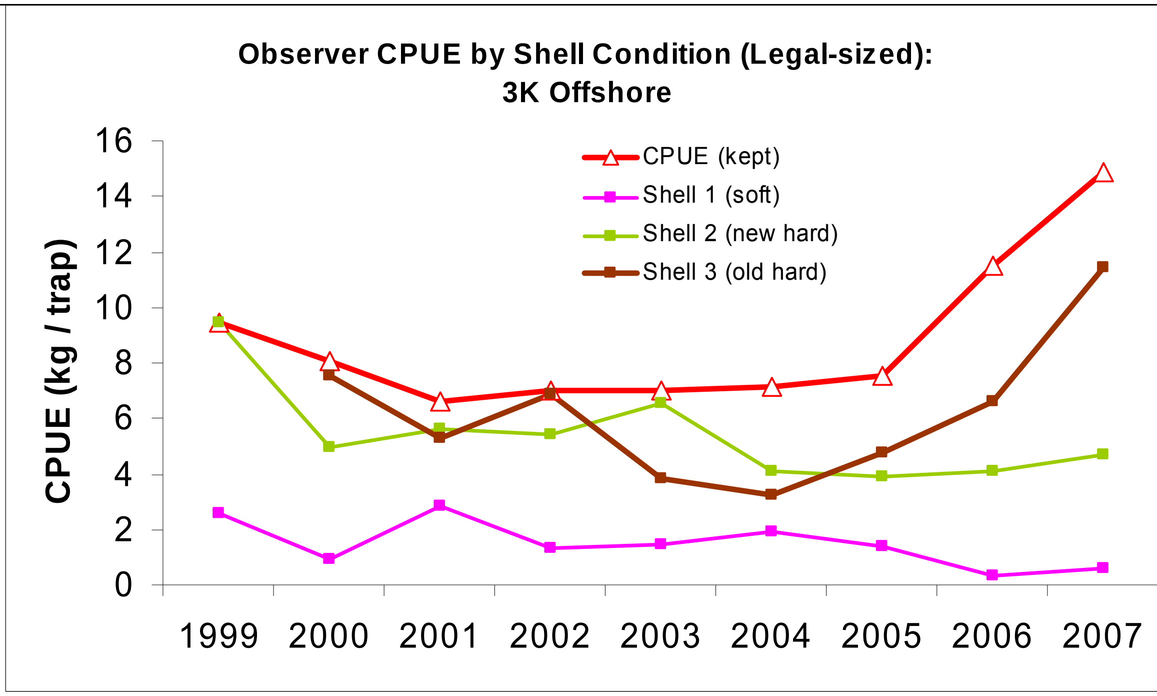


Figure 44. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Division 3K offshore. The vertical dashed line indicates the minimum legal size.

a)



b)

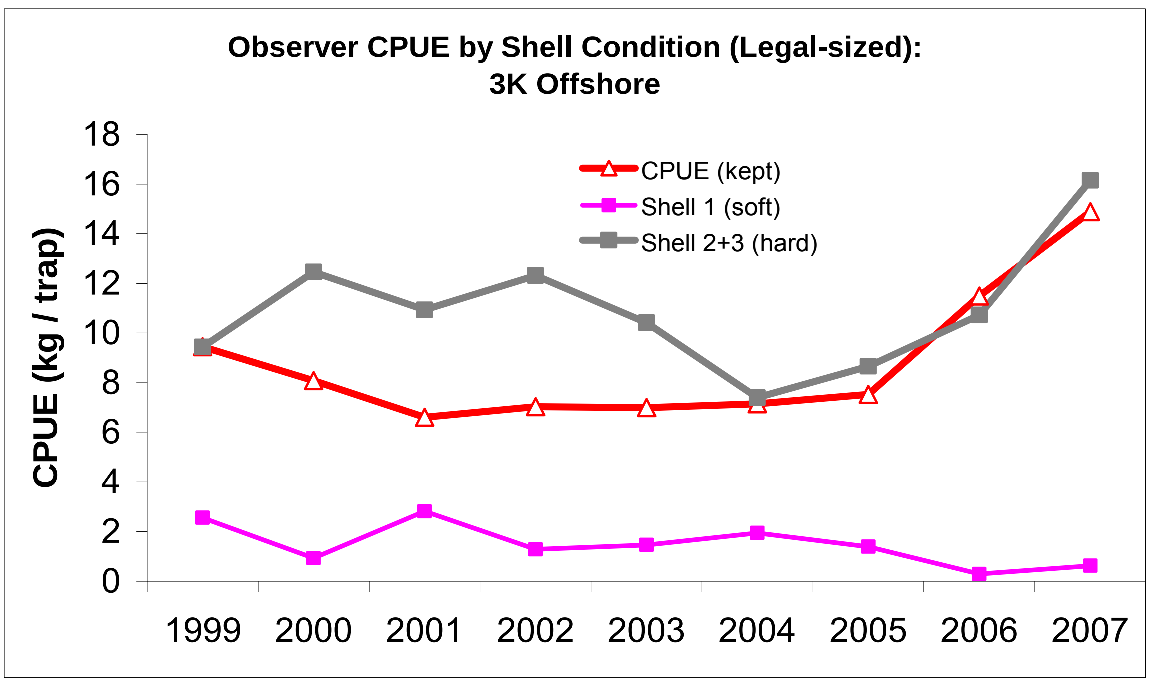


Figure 45. Trends in Division 3K offshore observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

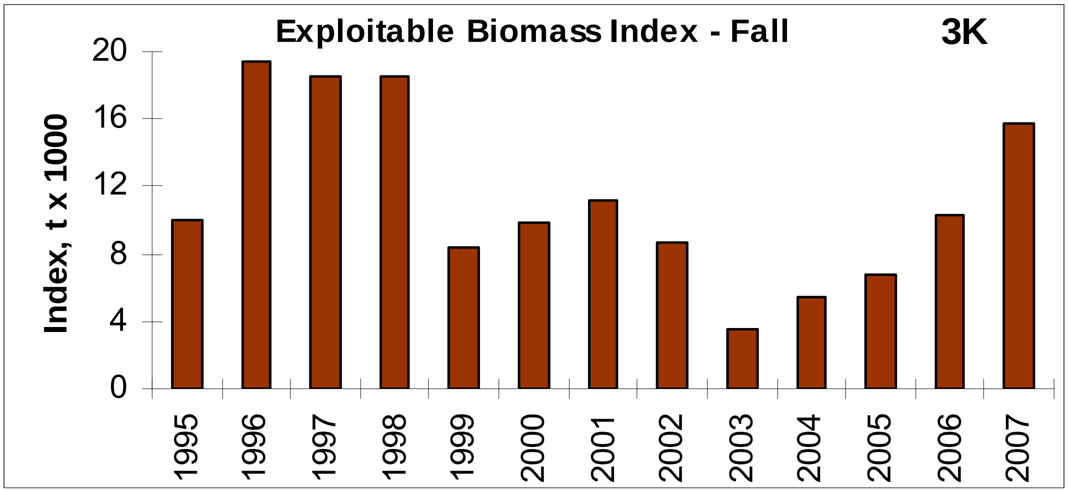


Figure 46. Trends in the Division 3K fall trawl survey exploitable biomass index.

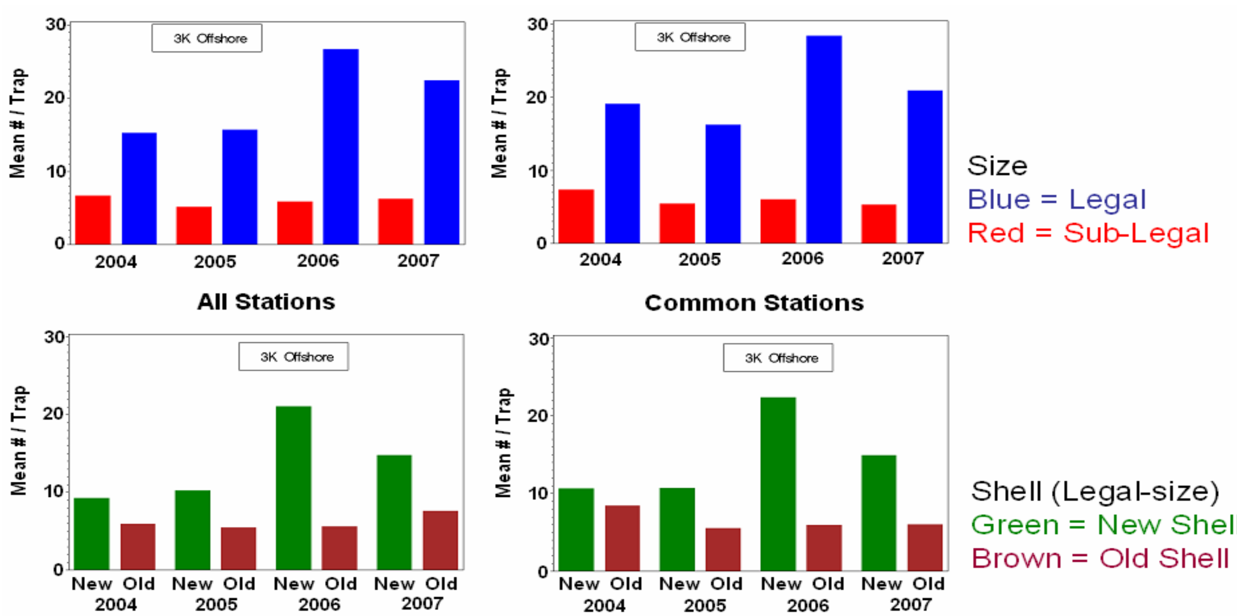


Figure 47. Trends in CPUE by size group (above) and by shell condition for legal-sized crabs (below) from industry-DFO collaborative post-season trap surveys for Division 3K offshore from all stations (left) and common stations (right).

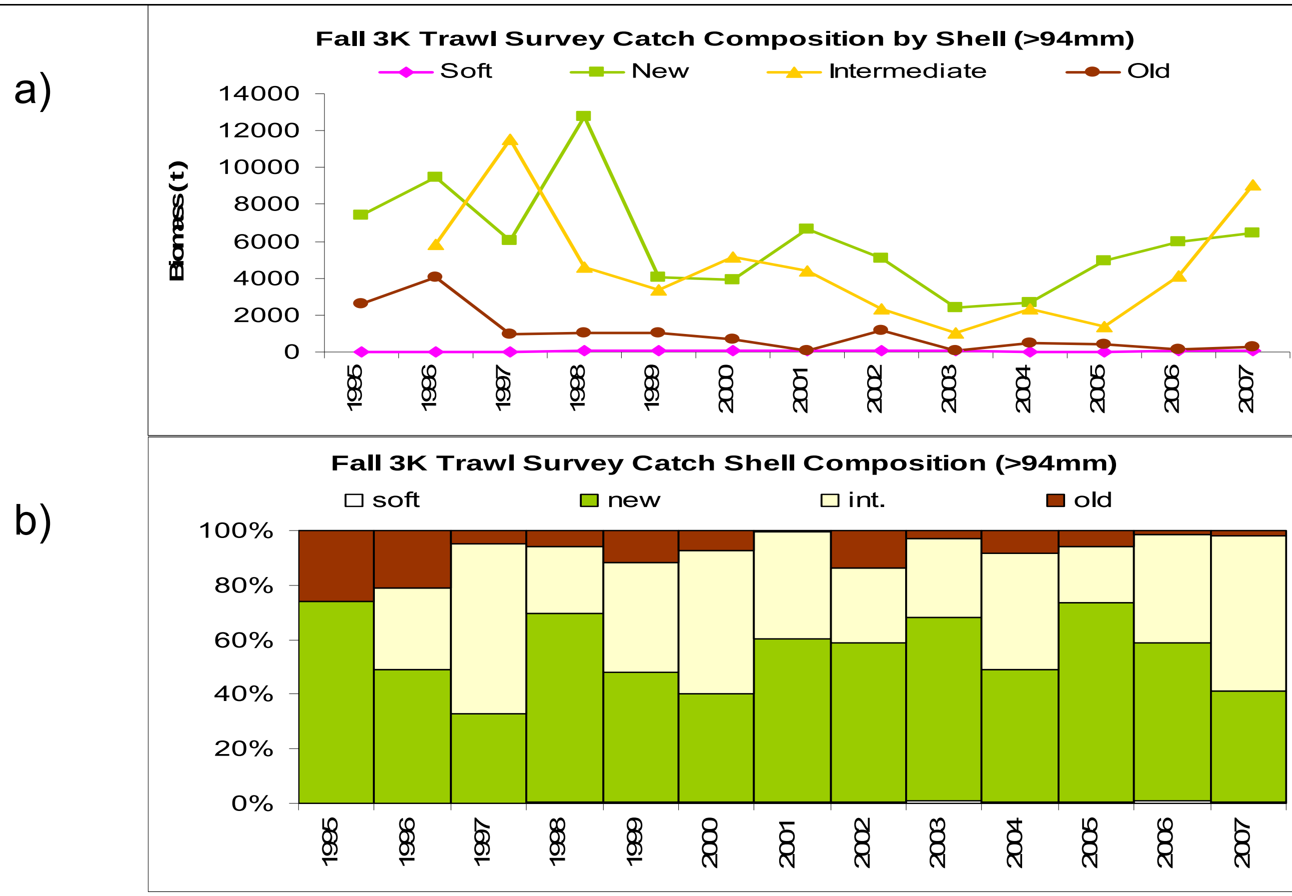


Figure 48. Trends, by shell condition, in legal-sized males for Division 3K offshore from fall trawl surveys for; a) biomass, and (b) percentages of the total catch.

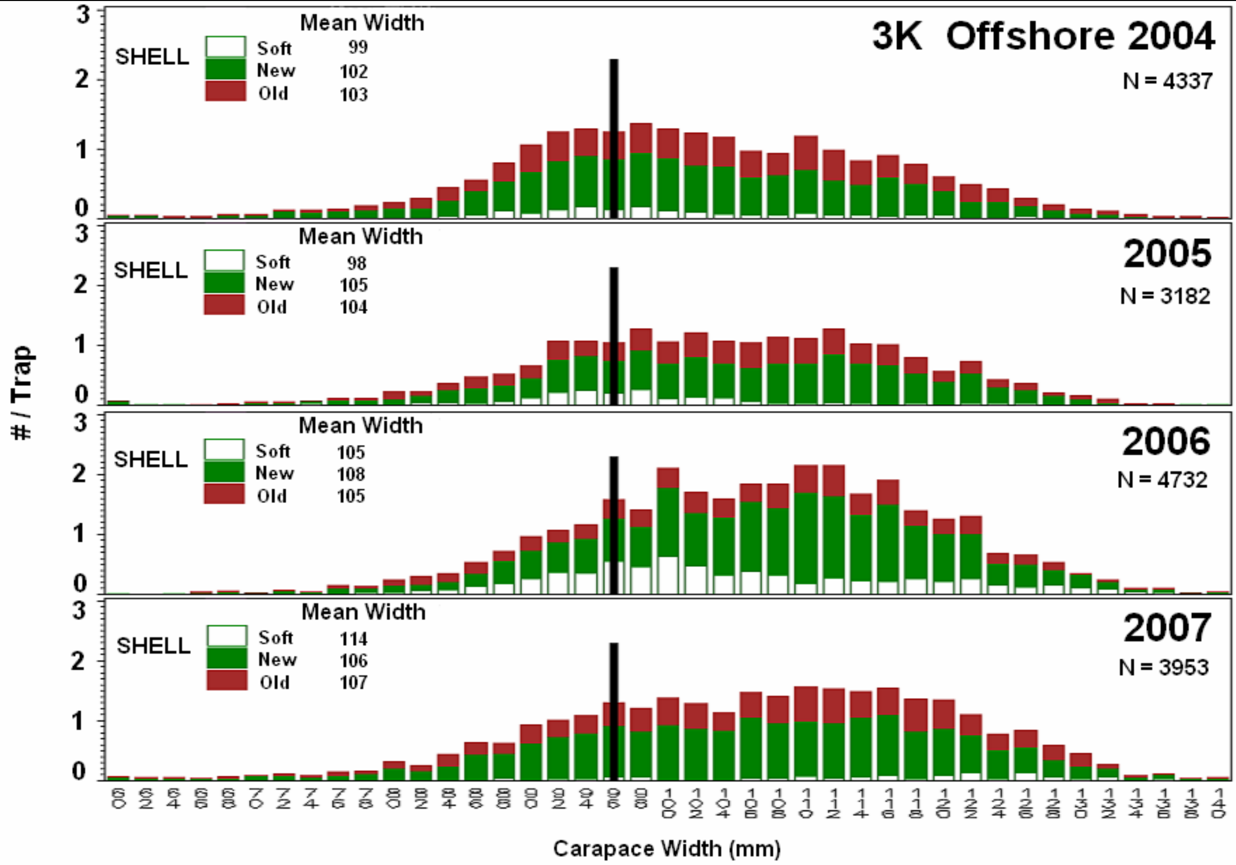


Figure 49. Trends in male carapace width distributions from industry-DFO collaborative trap surveys for Division 3K offshore (all stations). The vertical solid line indicates the minimum legal size.

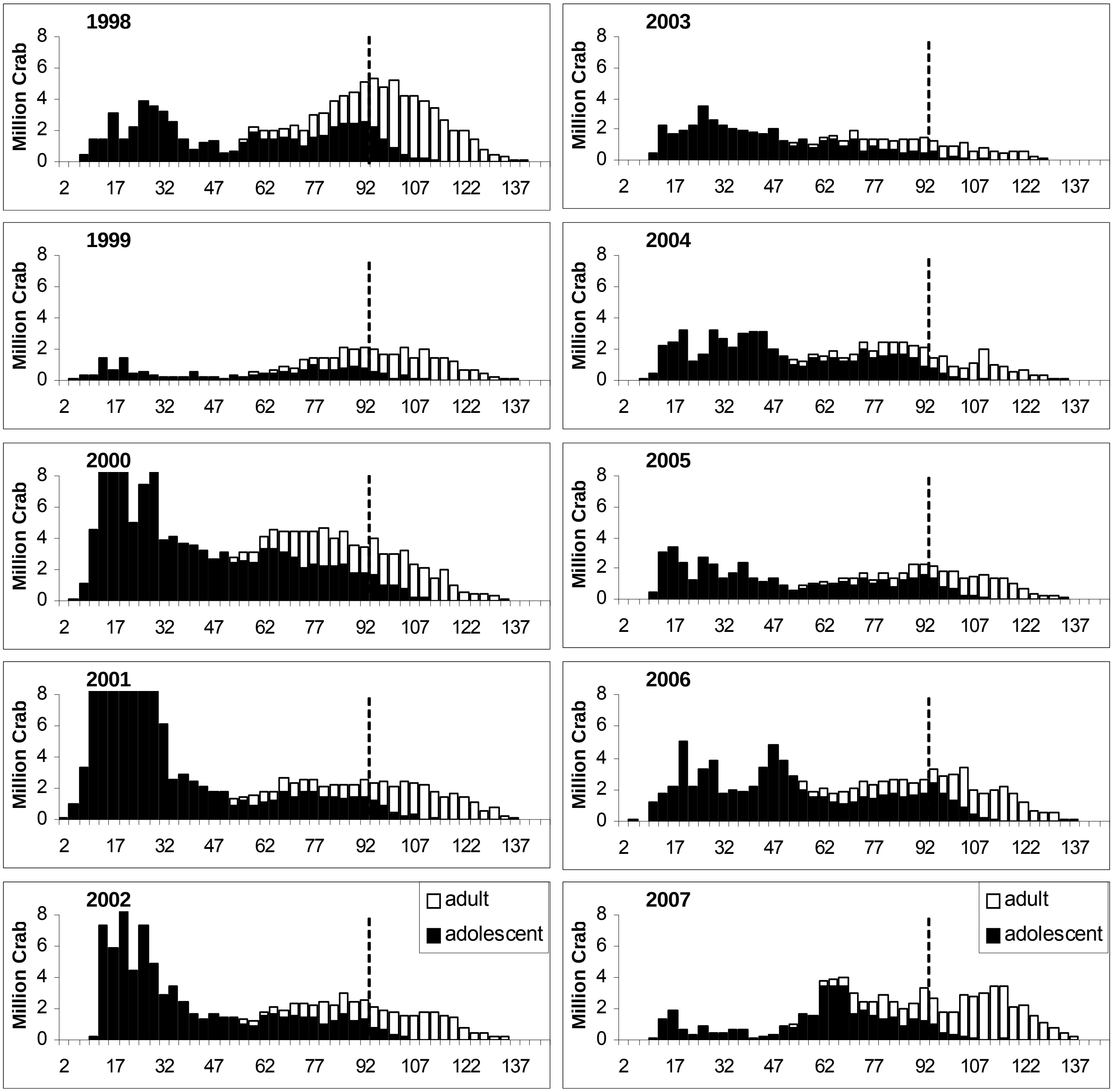


Figure 50. Distribution of abundance (index) by carapace width for Division 3K juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50 mm Cw). The minimum legal size is indicated by a vertical dashed line.

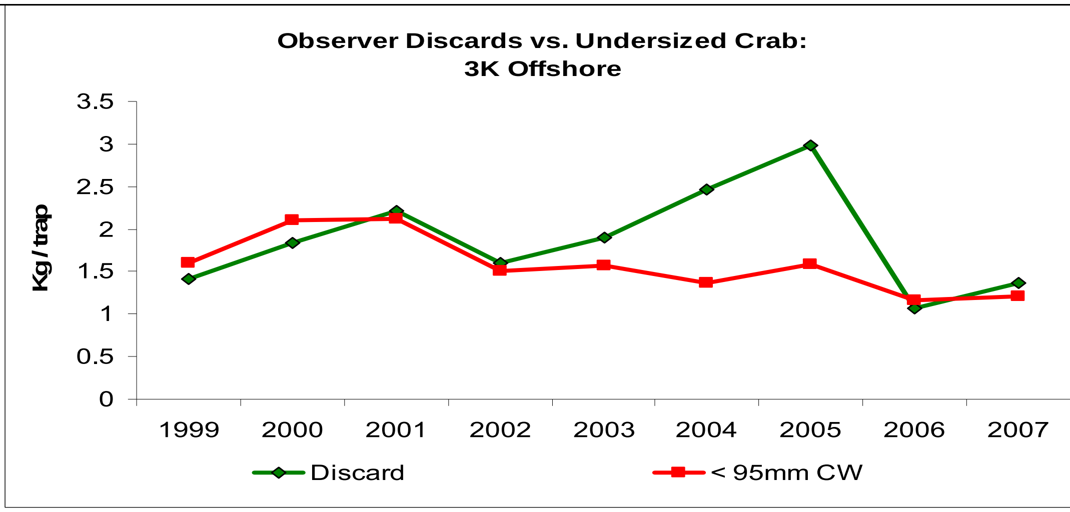


Figure 51. Trends in Division 3K offshore observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

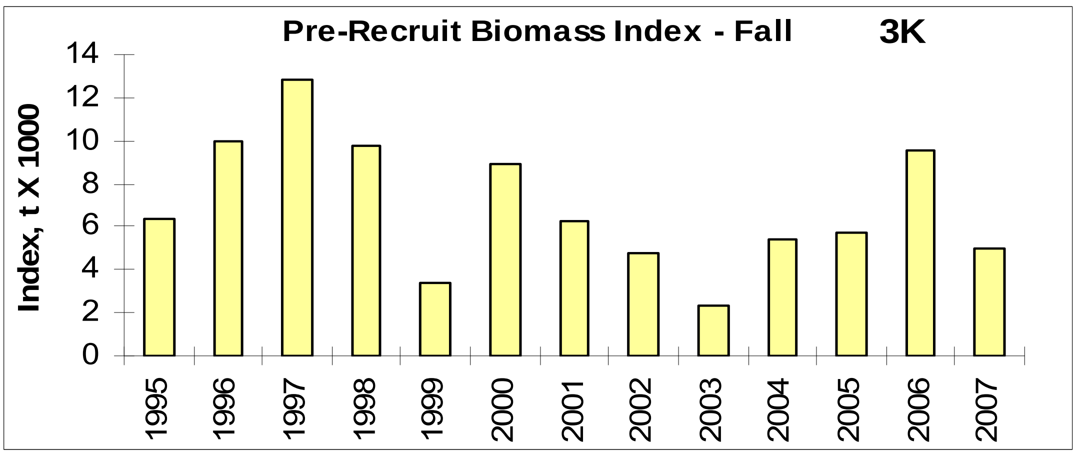


Figure 52. Trends in the Division 3K fall trawl survey pre-recruit biomass index.

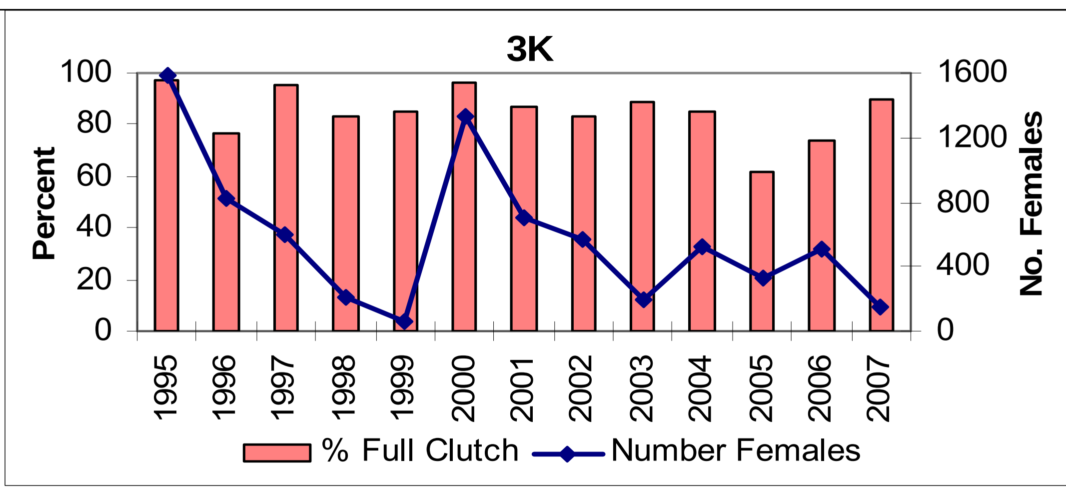


Figure 53. Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 3K from fall multi-species surveys.

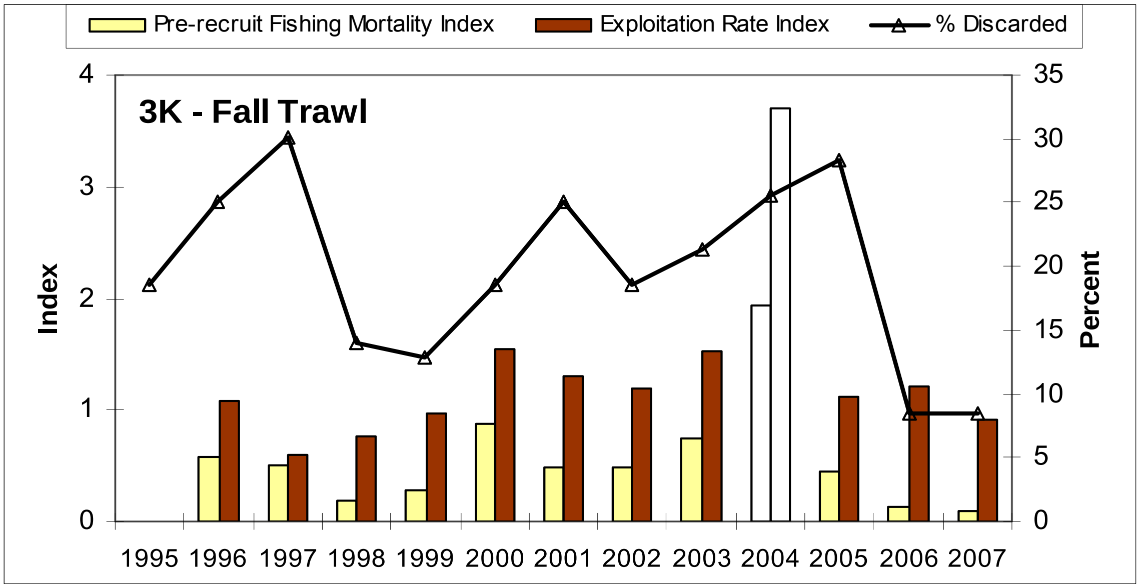


Figure 54. Trends in Division 3K offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery (anomalously high 2004 values are attributable to low catch rates in 2003 trawl survey).

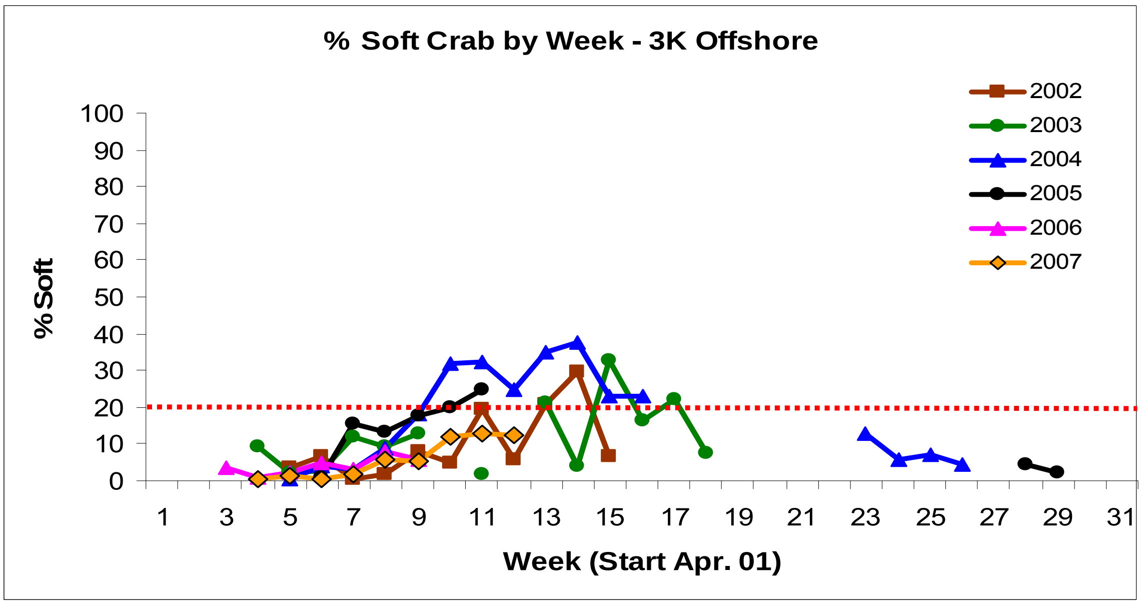


Figure 55. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Division 3K offshore fishery that are soft-shelled, by year (2002-07), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed.)

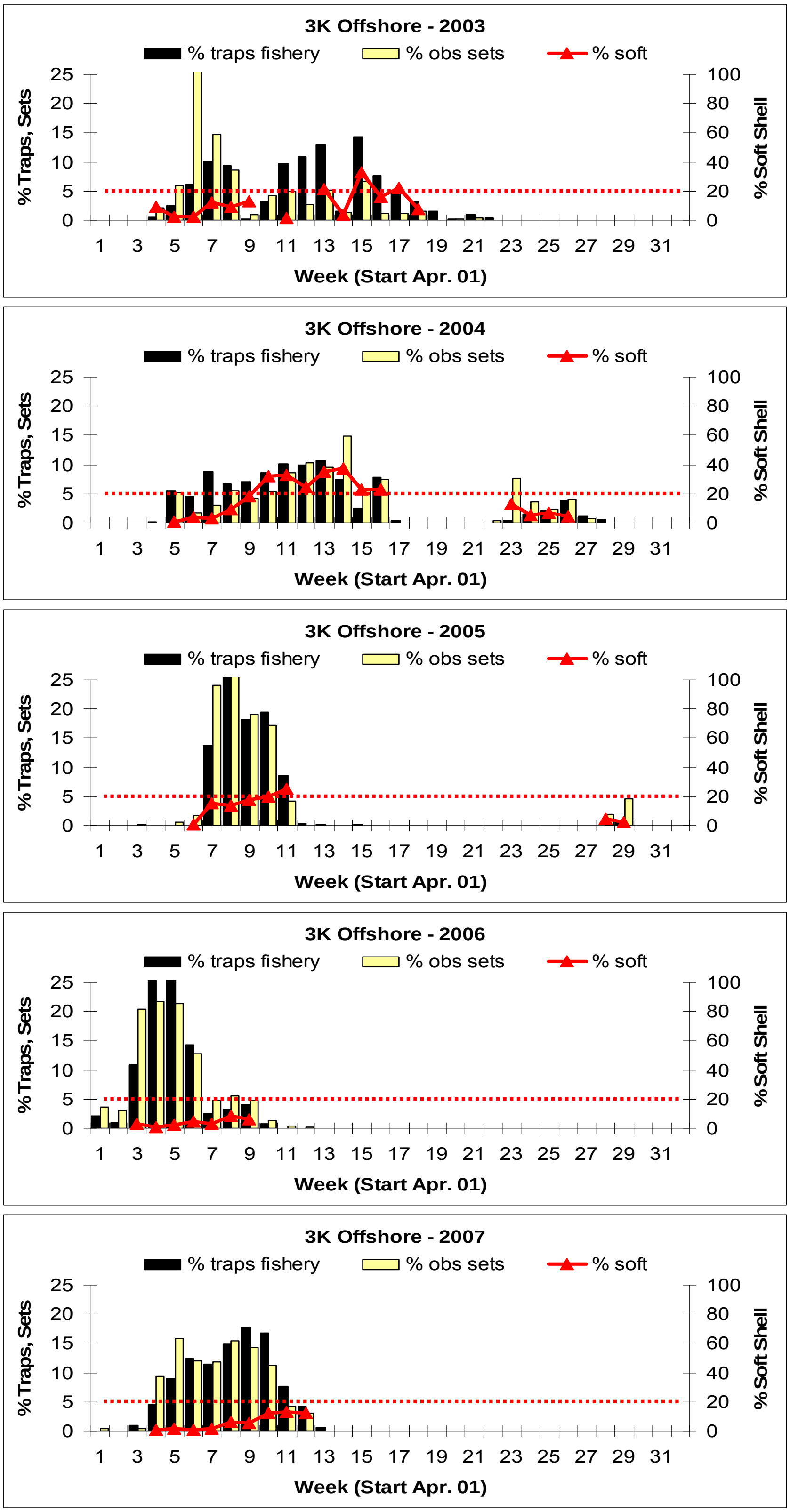


Figure 56. Seasonal trends in Division 3K offshore distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2003-07. (Sample sizes of <10 observed sets/week removed.)

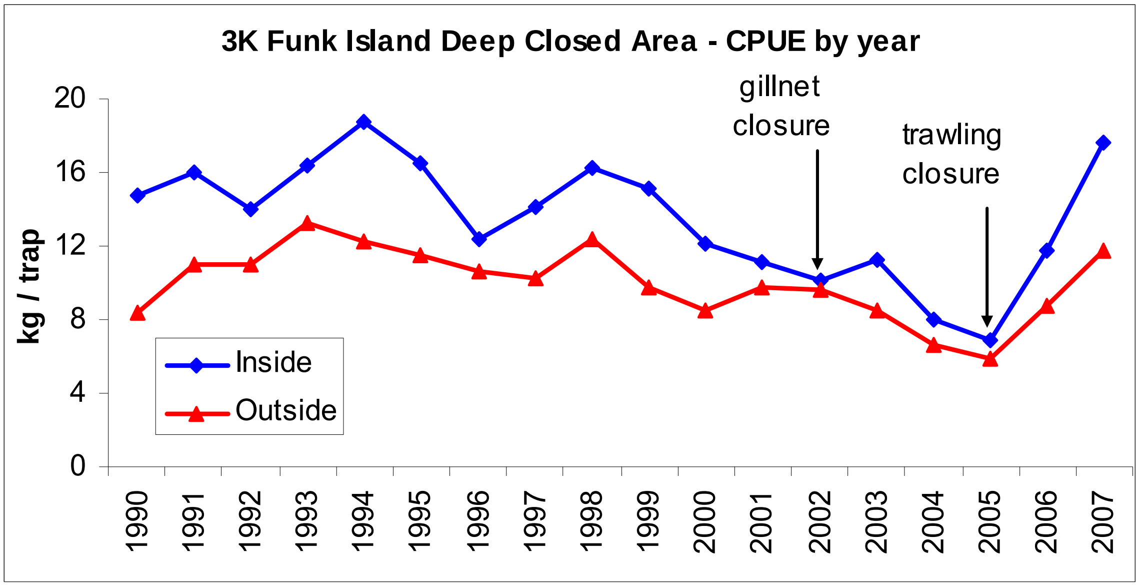


Figure 57. Division 3K offshore commercial CPUE; inside vs. outside the Funk Island Deep closed area.

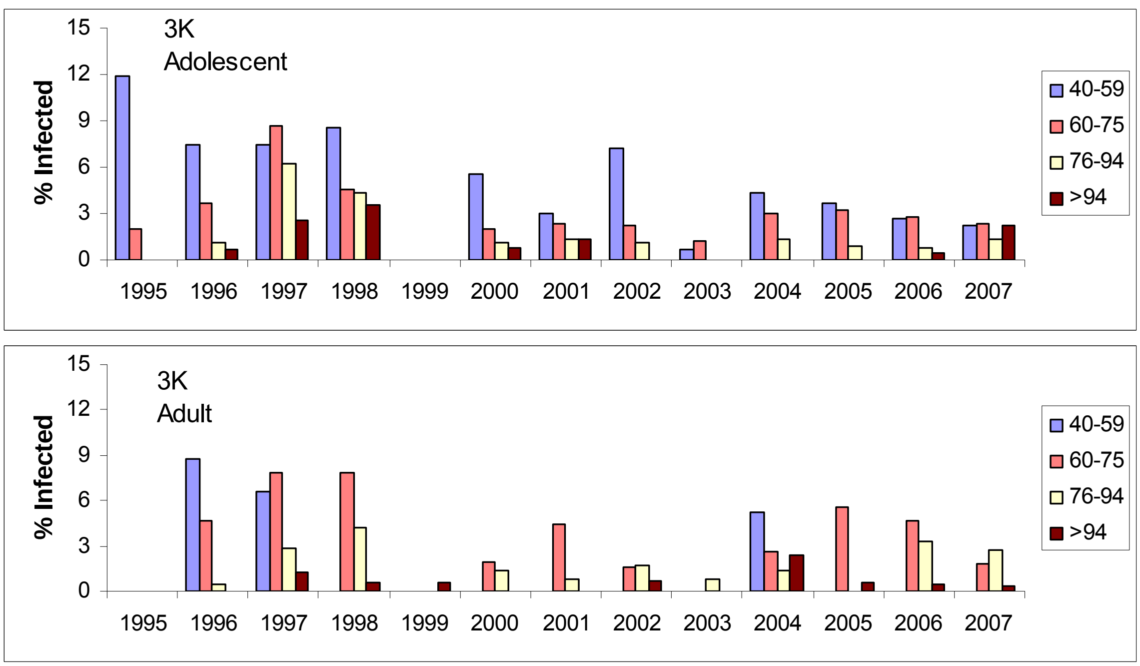


Figure 58. Trends in prevalence of BCD in new-shelled adolescents (above) and adults (below) by male size group from Division 3K fall trawl surveys.

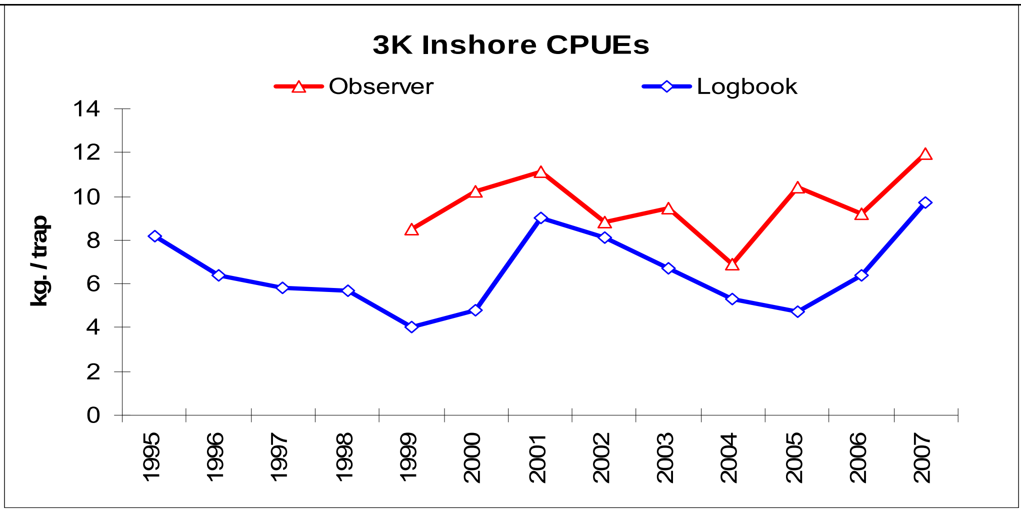


Figure 59. Trends in commercial logbook-based CPUE and observer-based CPUE in the Division 3K inshore fishery.

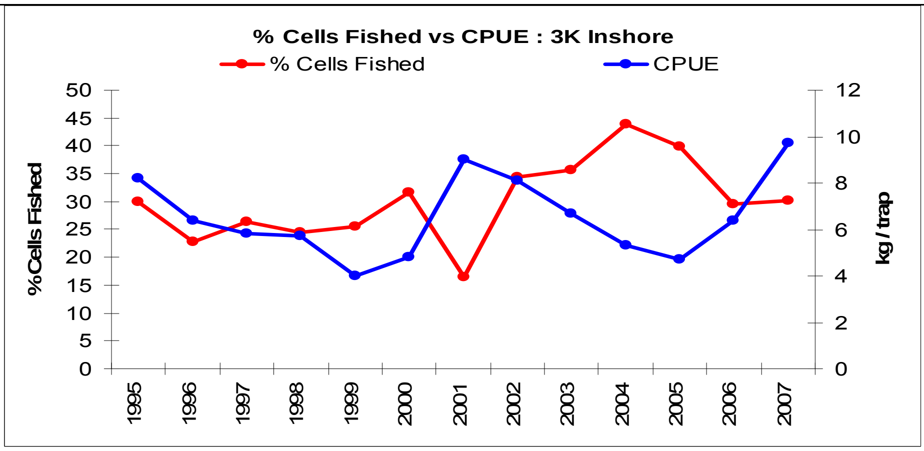


Figure 60. Trends in Division 3K inshore commercial CPUE vs. the percentage of 5’ x 5’ cells fished.

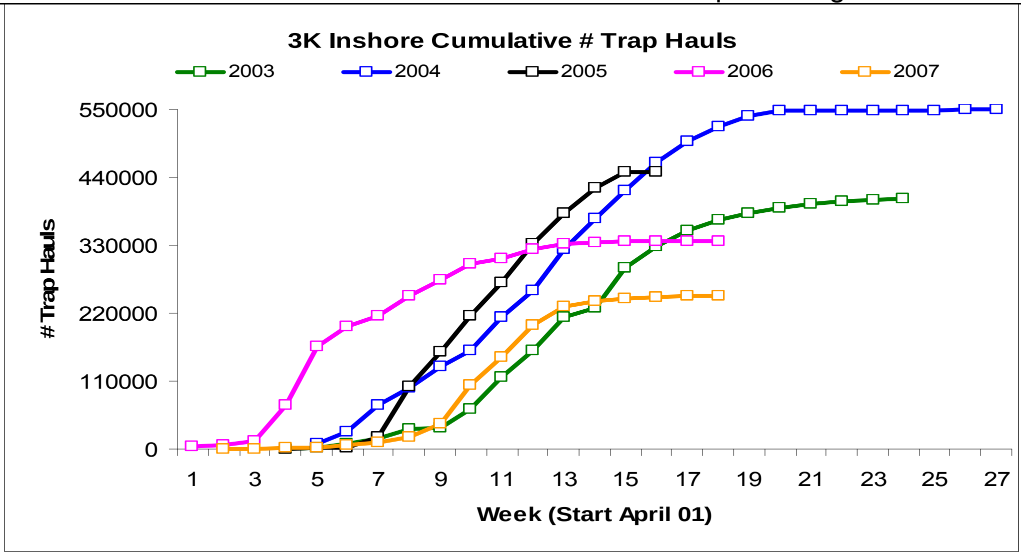


Figure 61. Seasonal trends in fishing effort for Division 3K inshore during 2003-07.

a)

b)

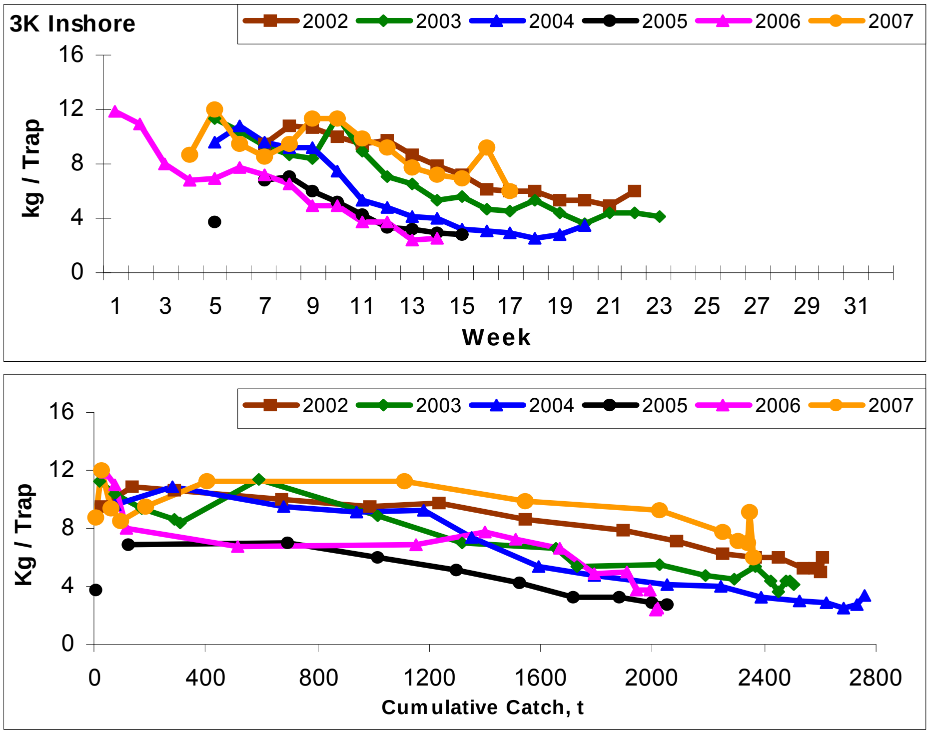


Figure 62. Seasonal trends in logbook-based CPUE for Division 3K inshore during 2002-2007; (a) by week, and (b) in relation to cumulative catch.

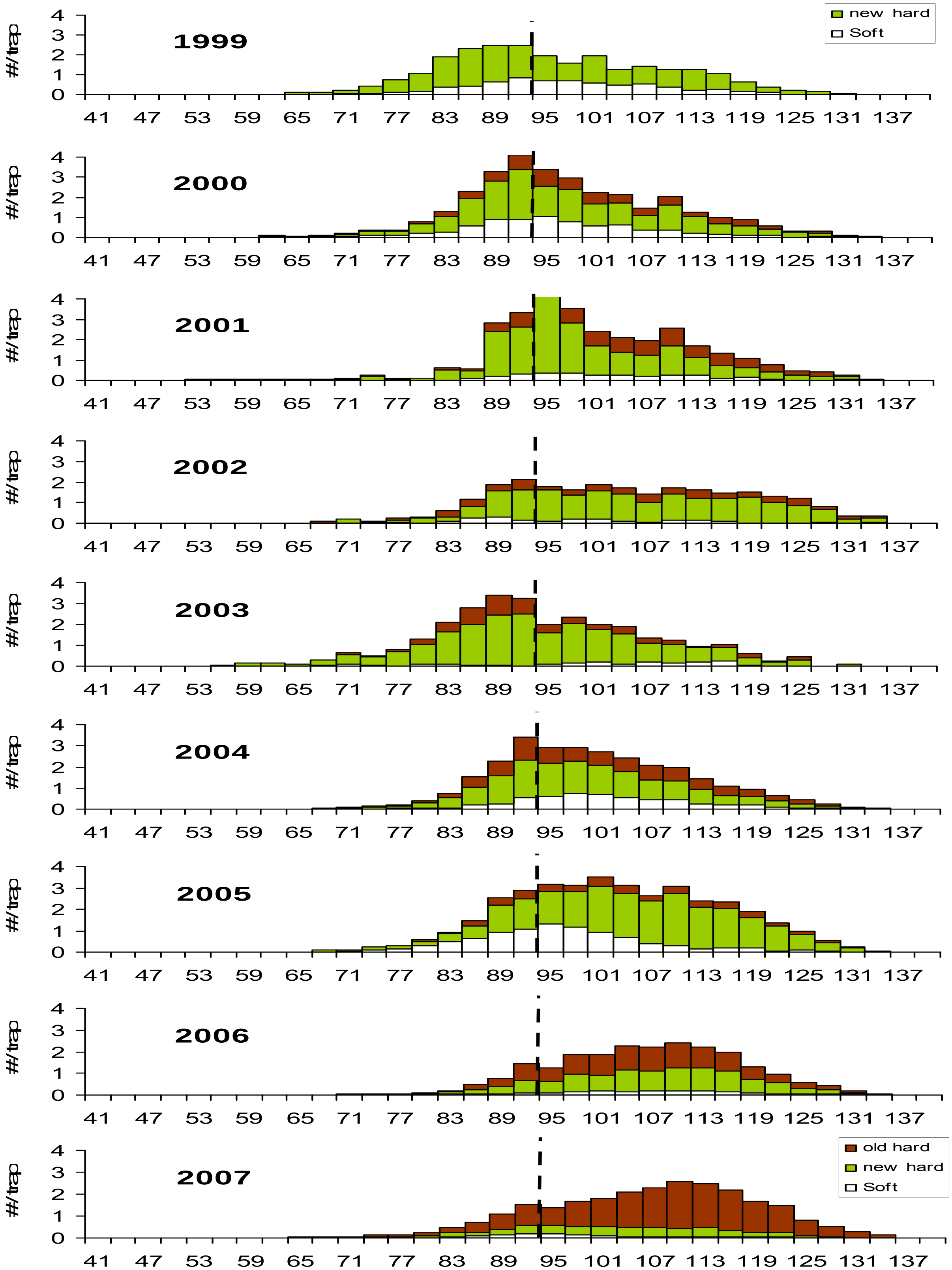
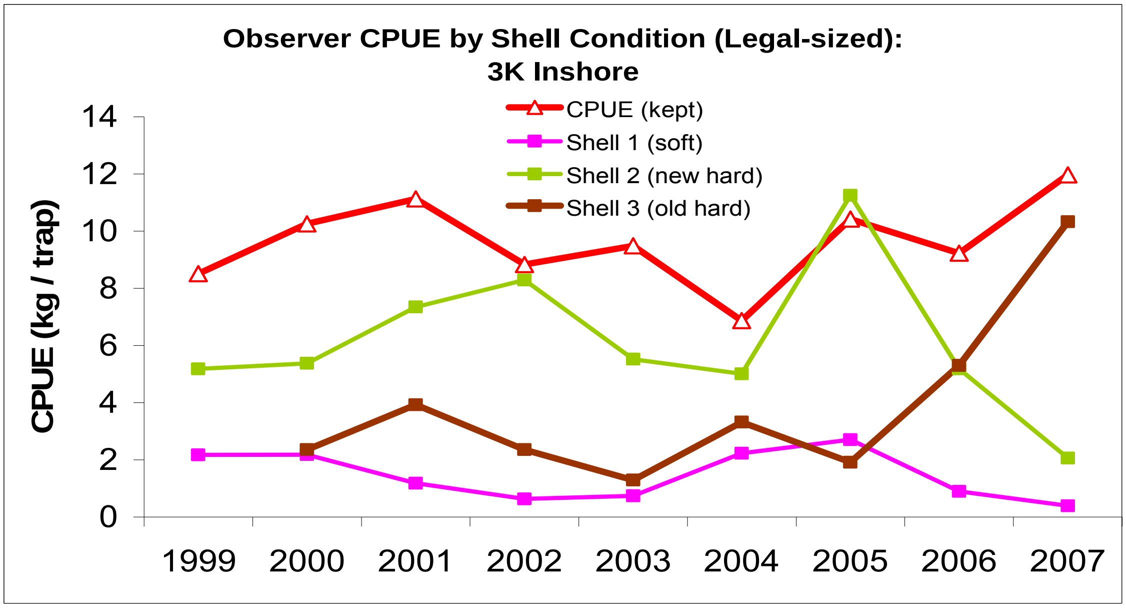


Figure 63. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Division 3K inshore. The vertical dashed line indicates the minimum legal size.

a)



b)

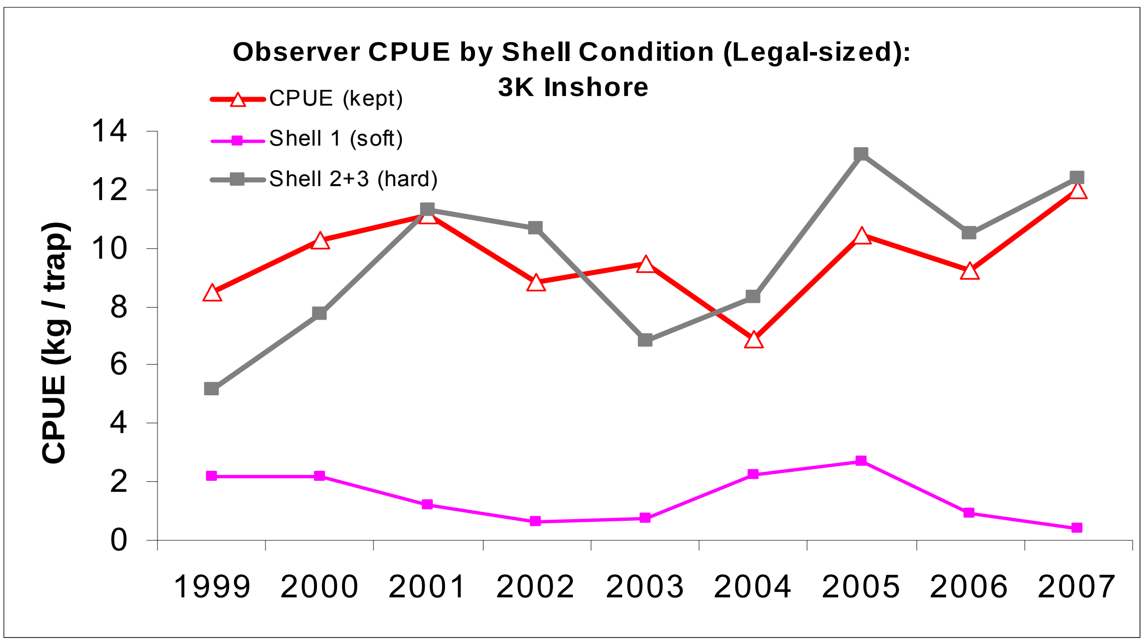


Figure 64. Trends in Division 3K inshore observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

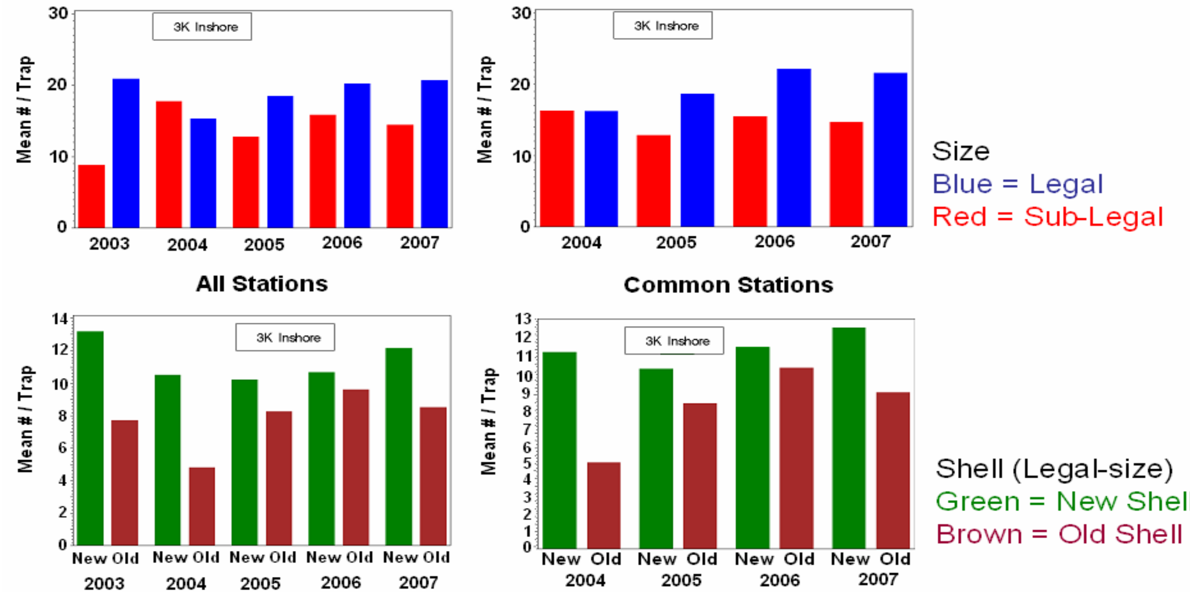


Figure 65. Trends in CPUE by size group (above) and shell condition for legal-sized crabs (below) from industry-DFO collaborative post-season trap surveys for Division 3K inshore from all stations (left) and common stations (right).

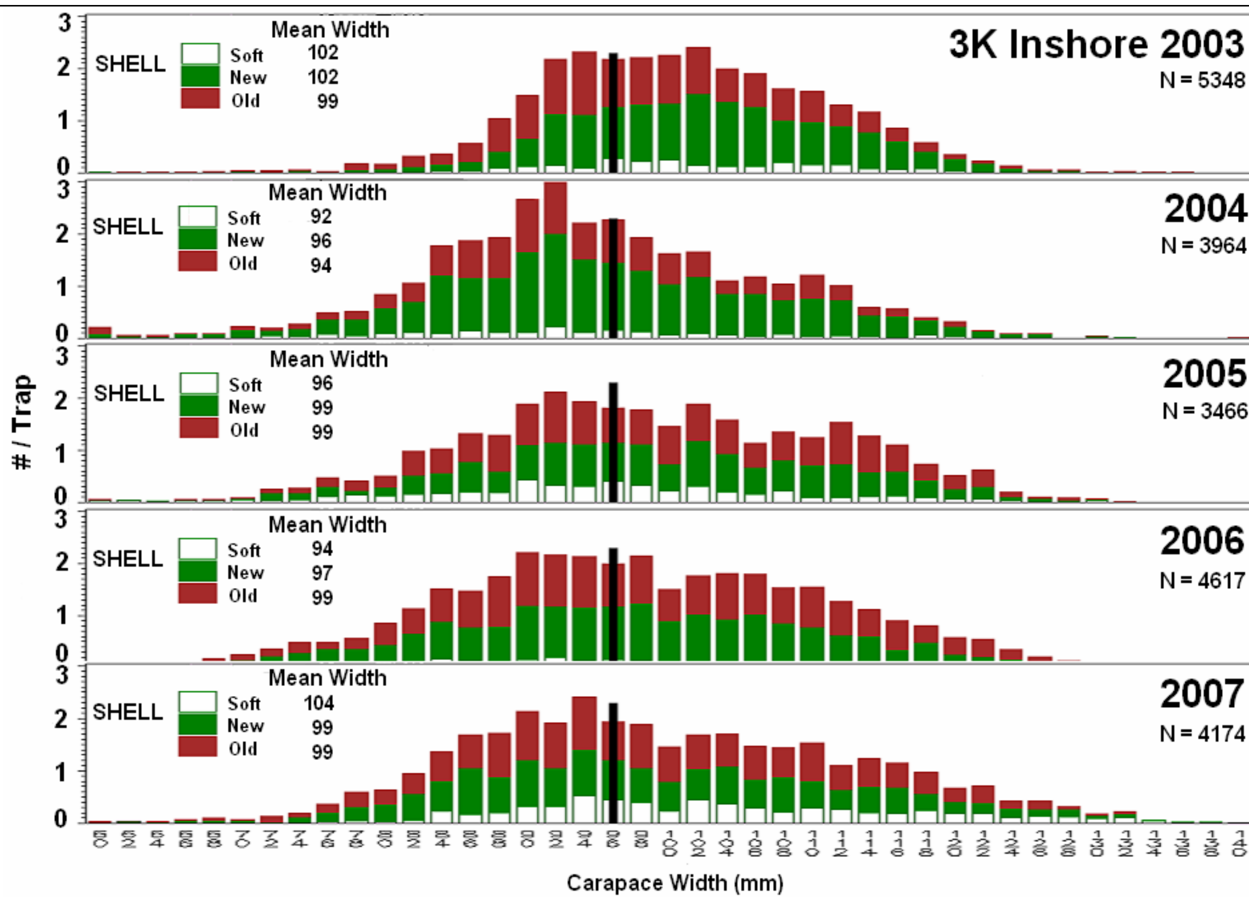


Figure 66. Trends in male carapace width distributions from industry-DFO collaborative post-season trap surveys (all stations) for Division 3K inshore.

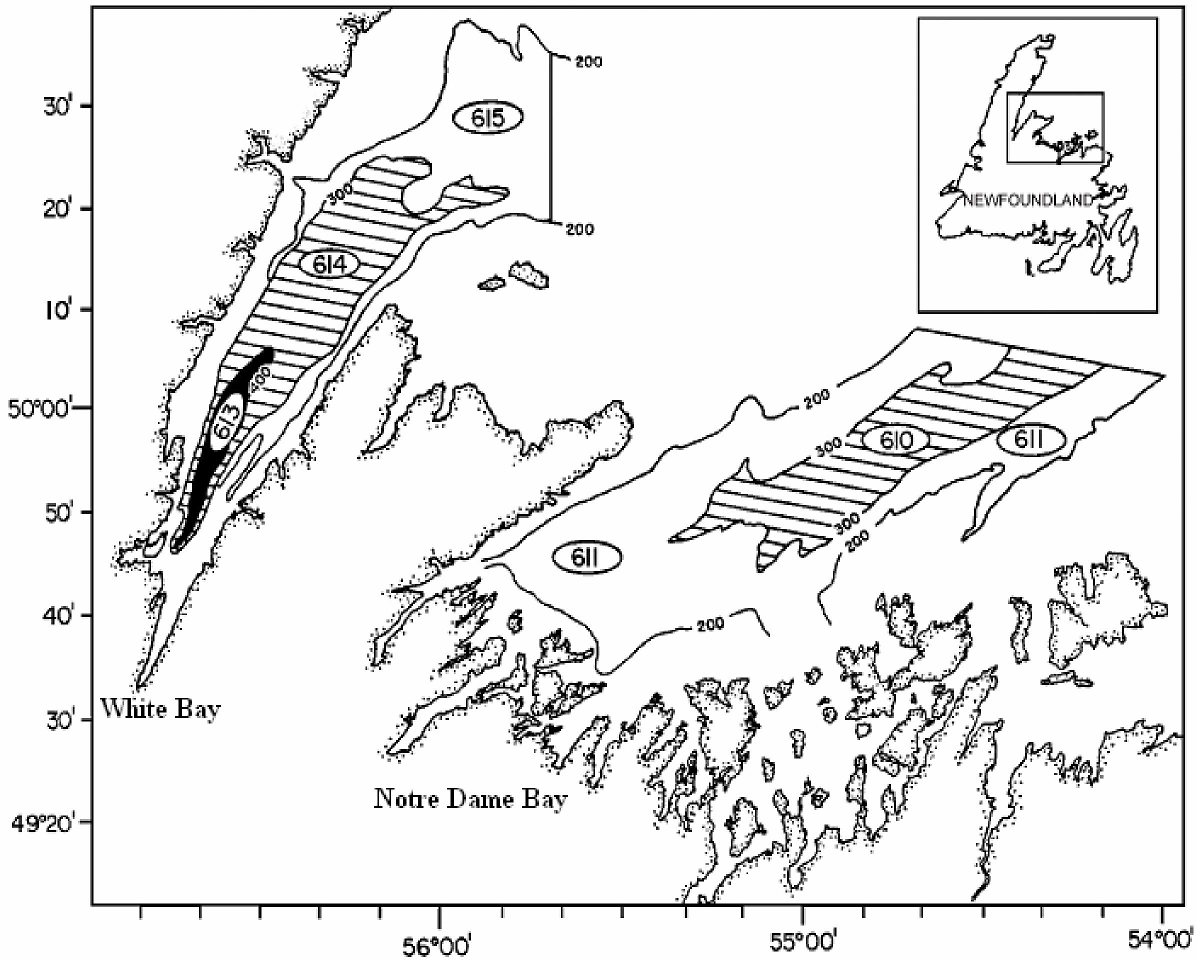


Figure 67. Location map showing inshore Division 3K strata sampled during fall trap surveys in White Bay and Notre Dame Bay.

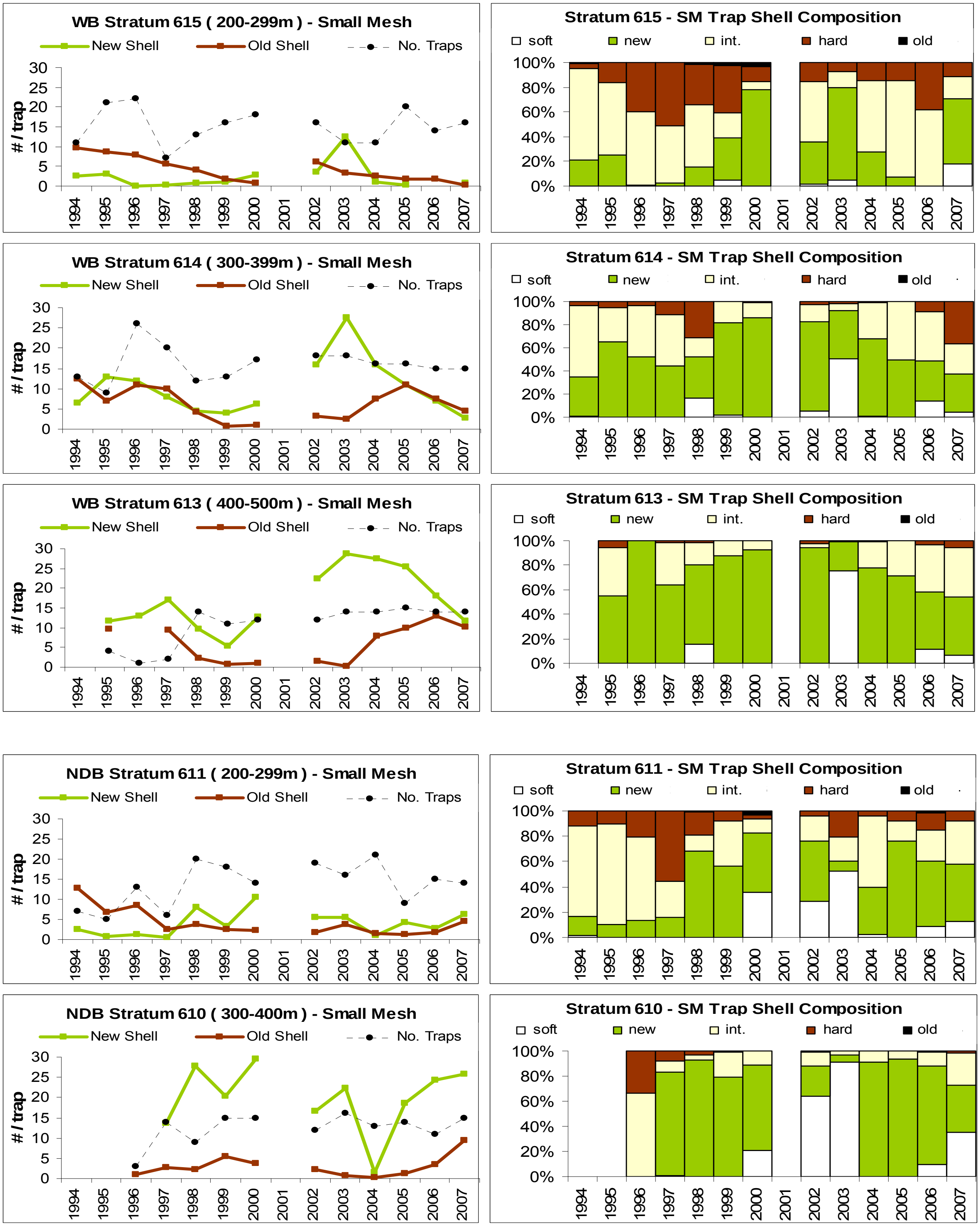


Figure 68a. Trends from small-mesh traps in shell condition of catches by stratum from inshore Division 3K trap surveys in White Bay (top panels) and Notre Dame Bay (bottom panels) 1994-2007; no survey was conducted in 2001.

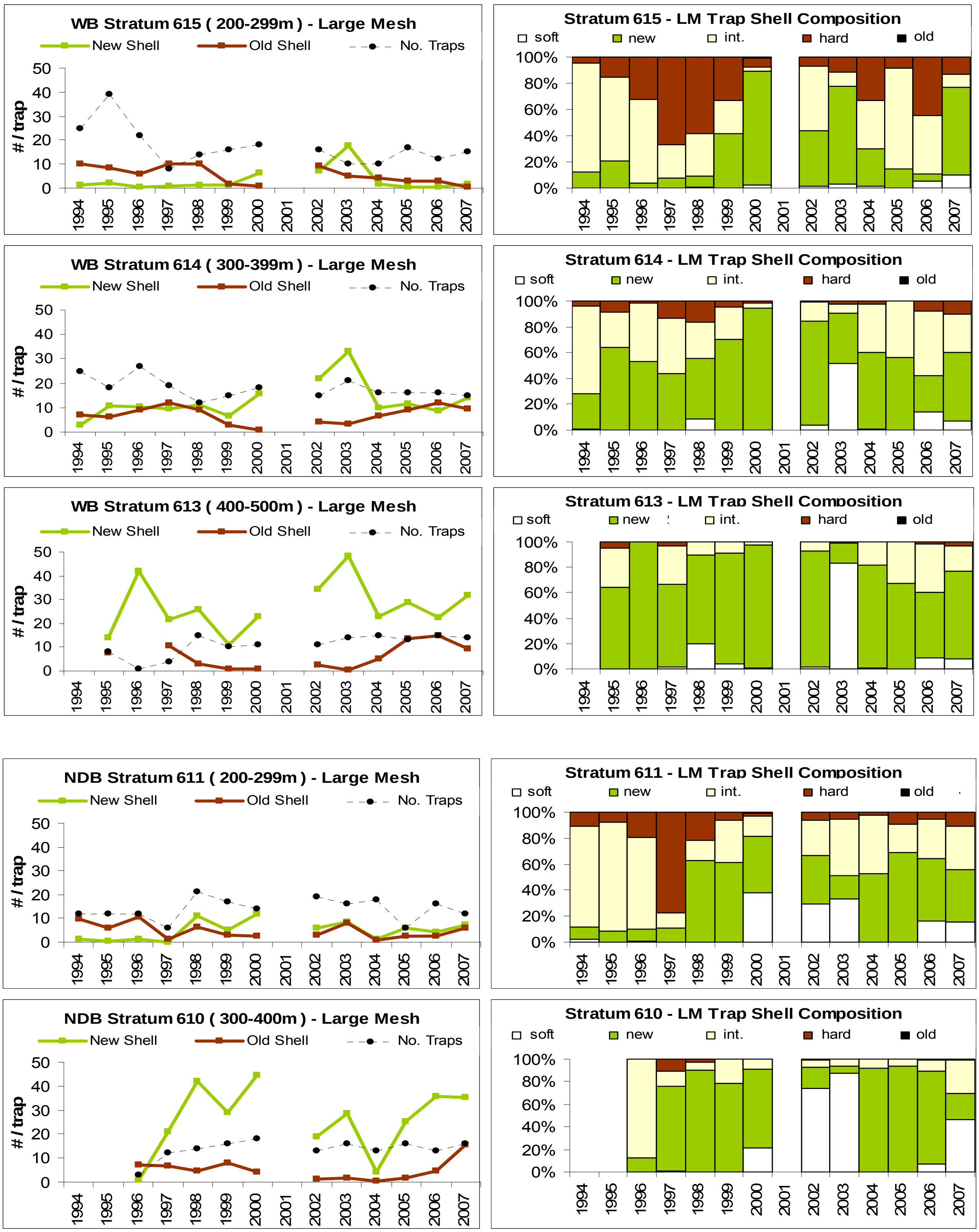


Figure 68b. Trends from large-mesh traps in shell condition of catches by stratum from inshore Division 3K trap surveys in White Bay (top panels) and Notre Dame Bay (bottom panels) 1994-2007; no survey was conducted in 2001.

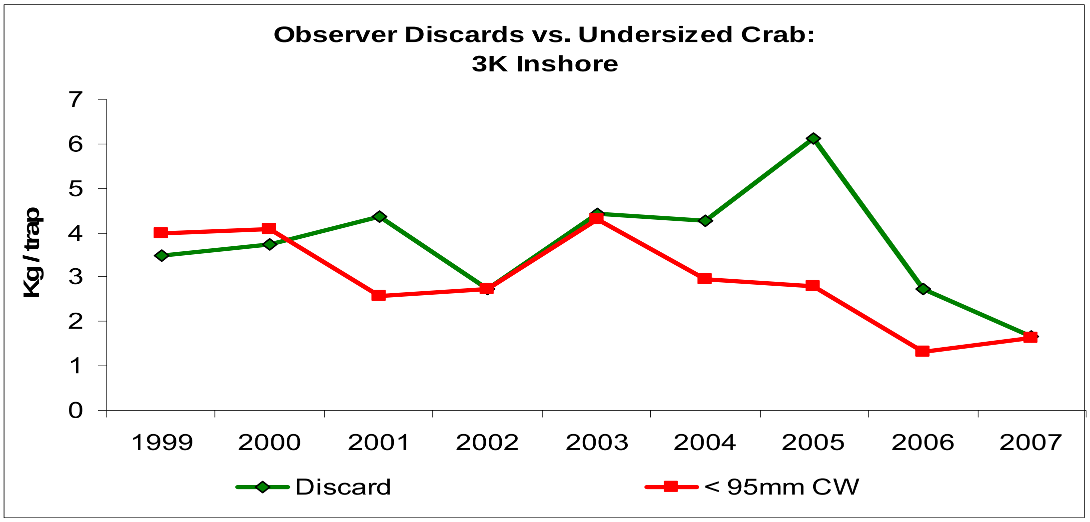


Figure 69. Trends in Division 3K inshore observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

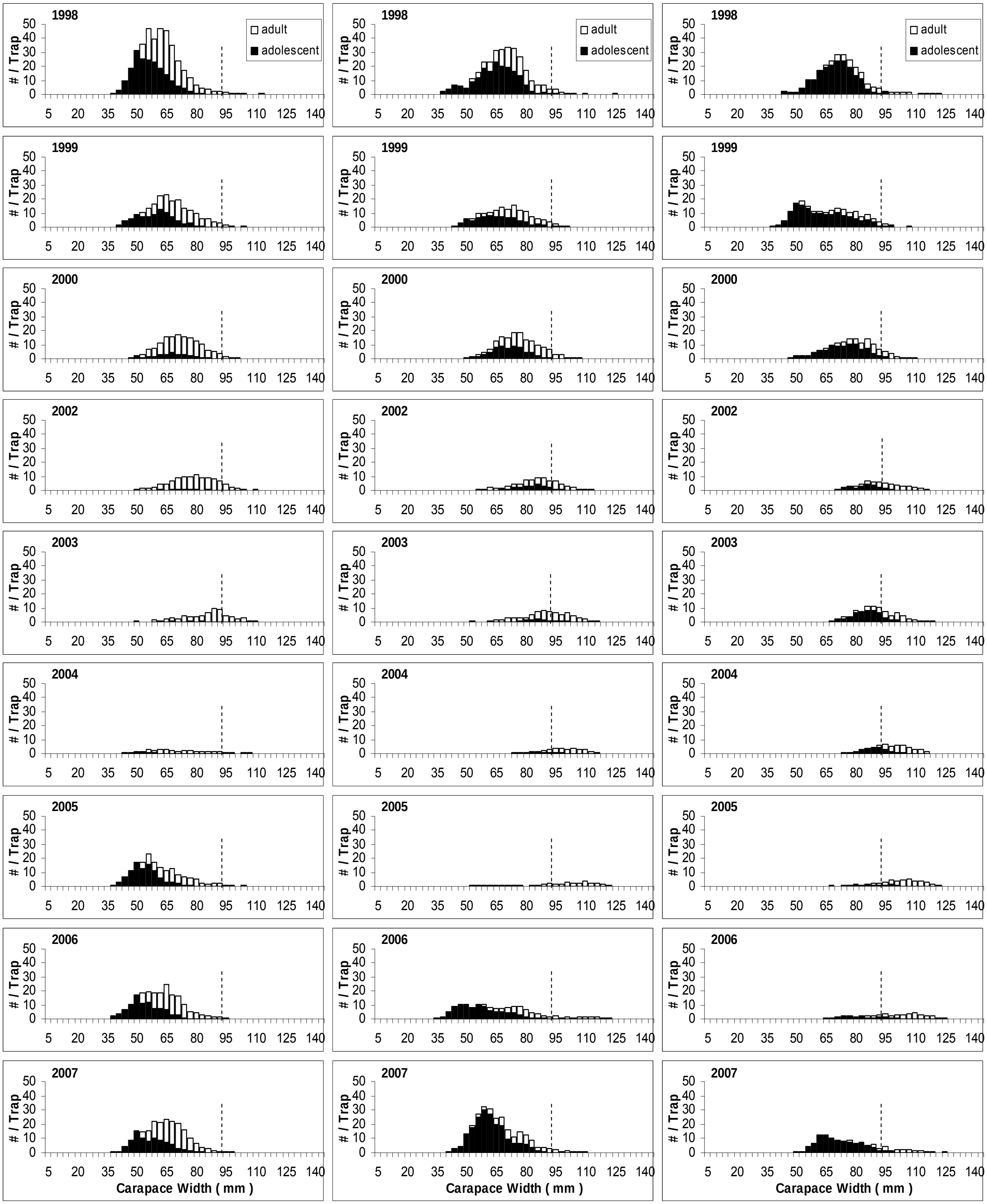


Figure 70. Inshore 3K trap surveys; small-claw (adolescent) vs. large-claw (adult) male crab size compositions by year from small-mesh traps within White Bay; Stratum 615 (200–299 m), Stratum 614 (300-399 m) and Stratum 613 (400-500 m).

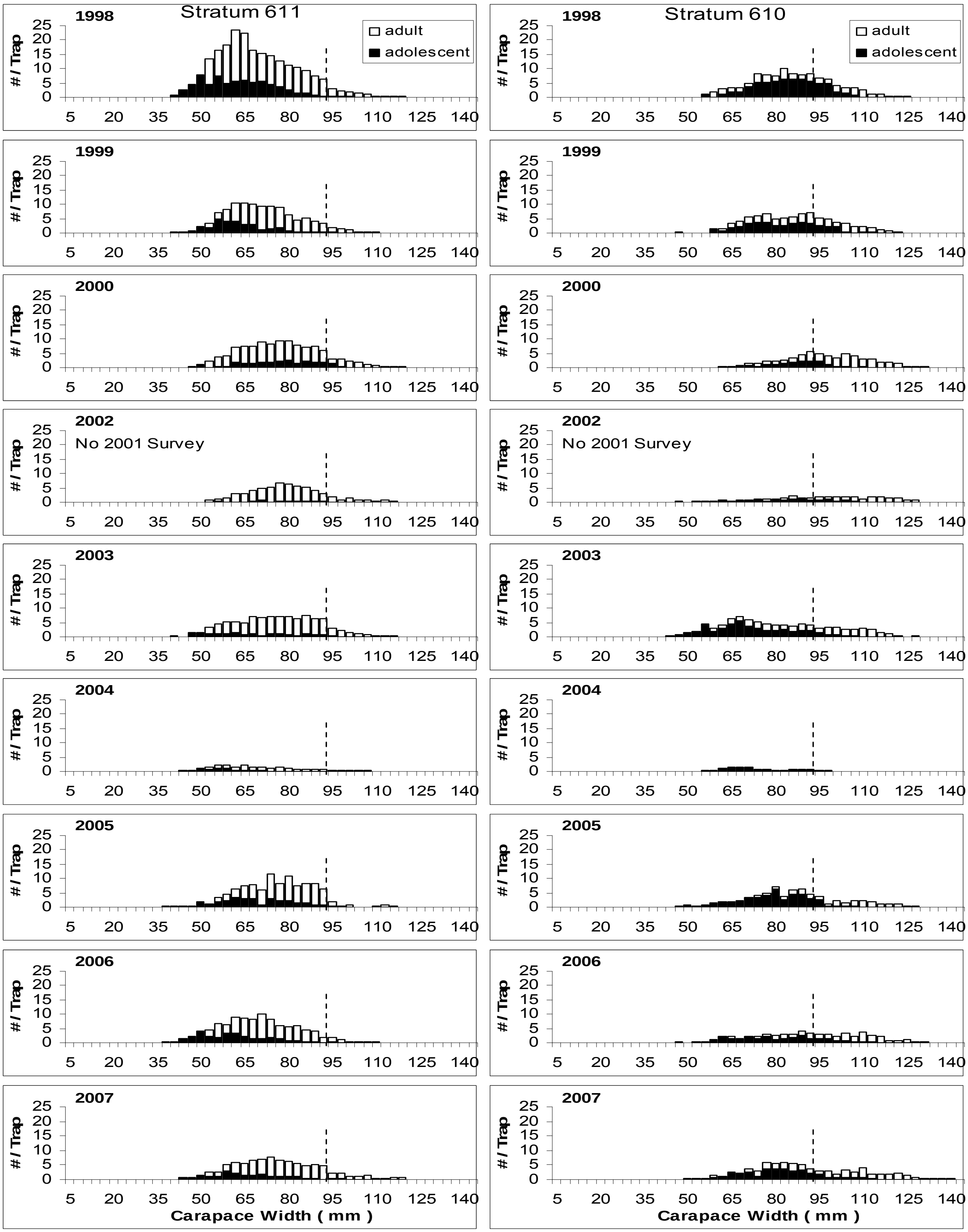


Figure 71. Inshore 3K trap surveys; small-claw (adolescent) vs. large-claw (adult) male crab size compositions by year from small-mesh traps within Notre Dame Bay; Stratum 611 (200–299 m) and Stratum 610 (300-399 m).

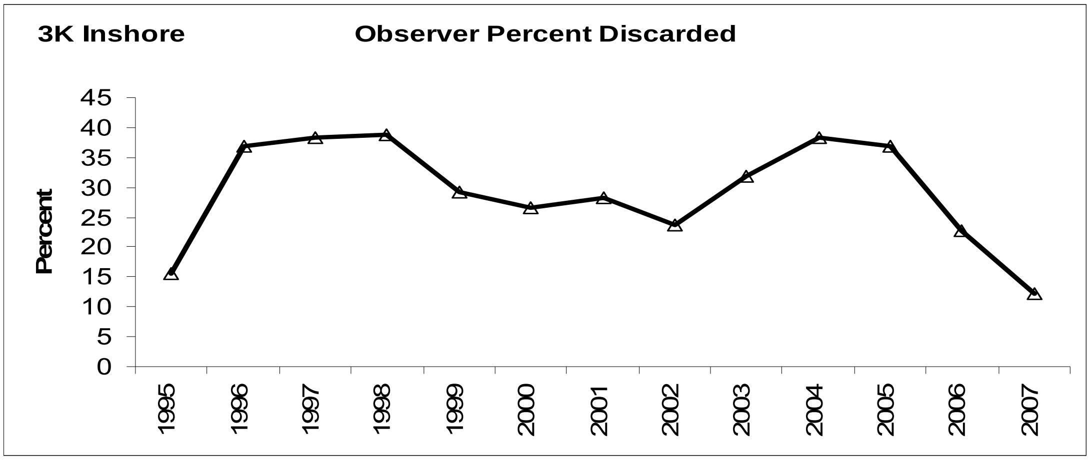


Figure 72. Trends in Division 3K inshore percentage of the catch discarded in the fishery.

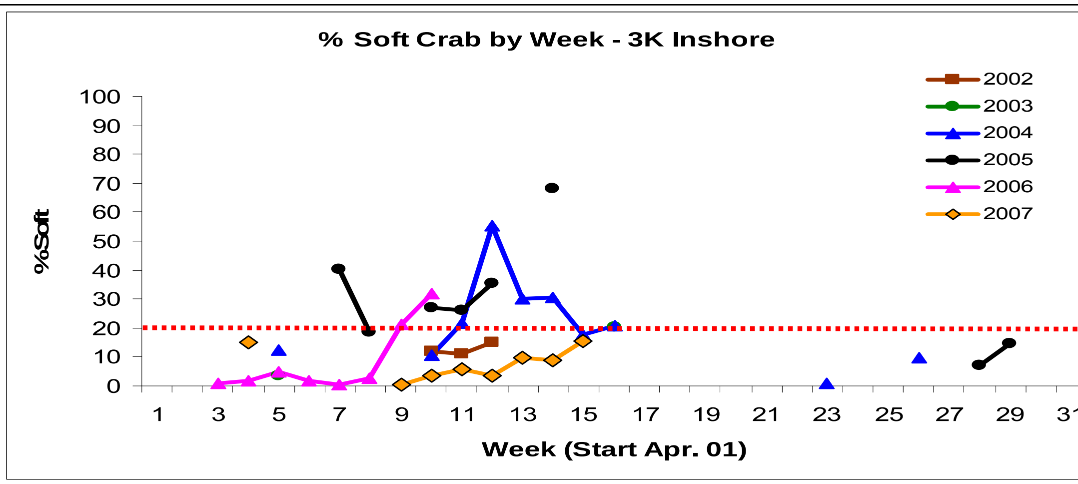


Figure 73. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Division 3K inshore fishery that are soft-shelled, by year (2002-2007), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed.)

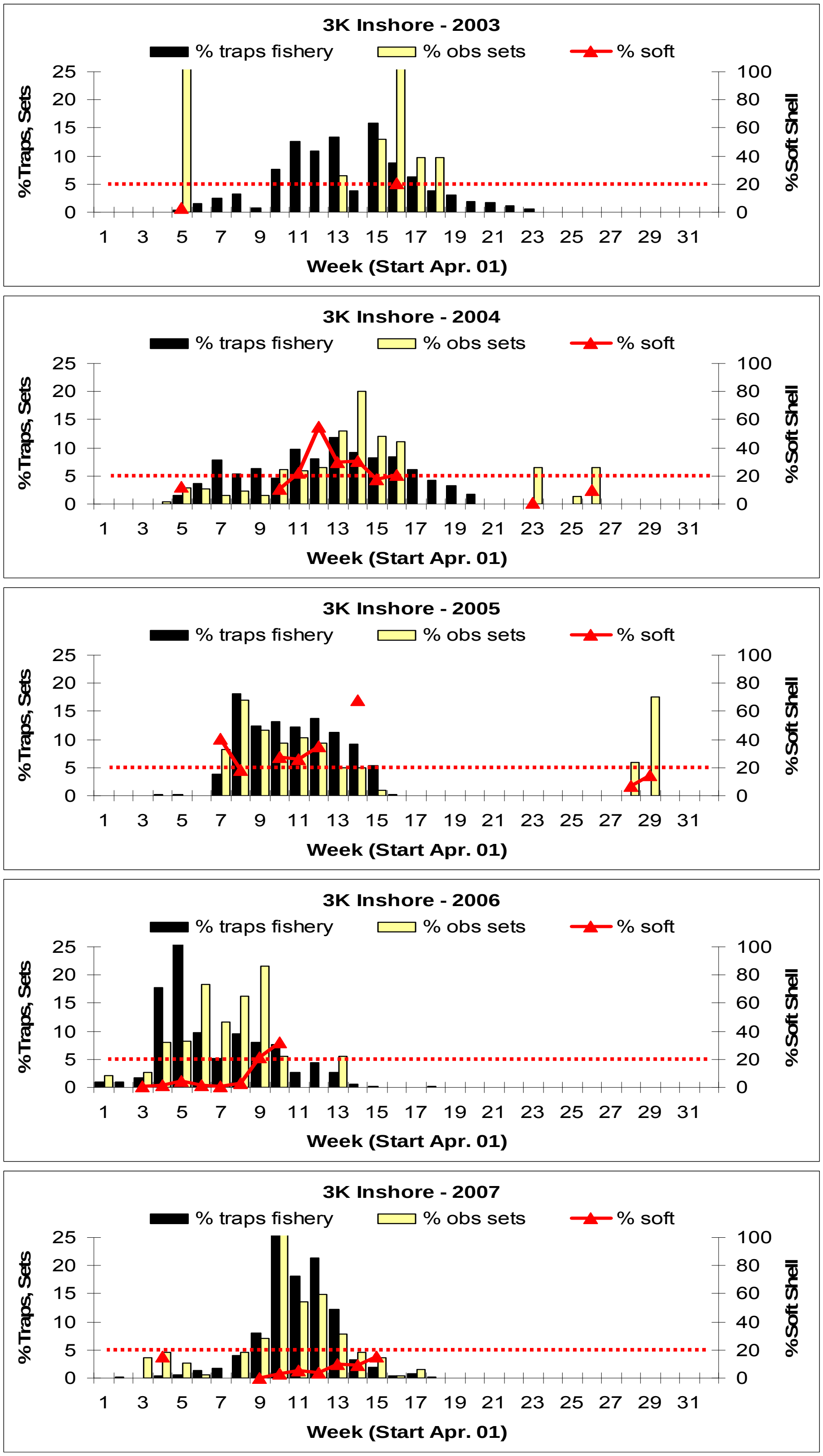


Figure 74. Seasonal trends in Division 3K inshore distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2003-07. (Sample sizes of <10 observed sets/week removed)

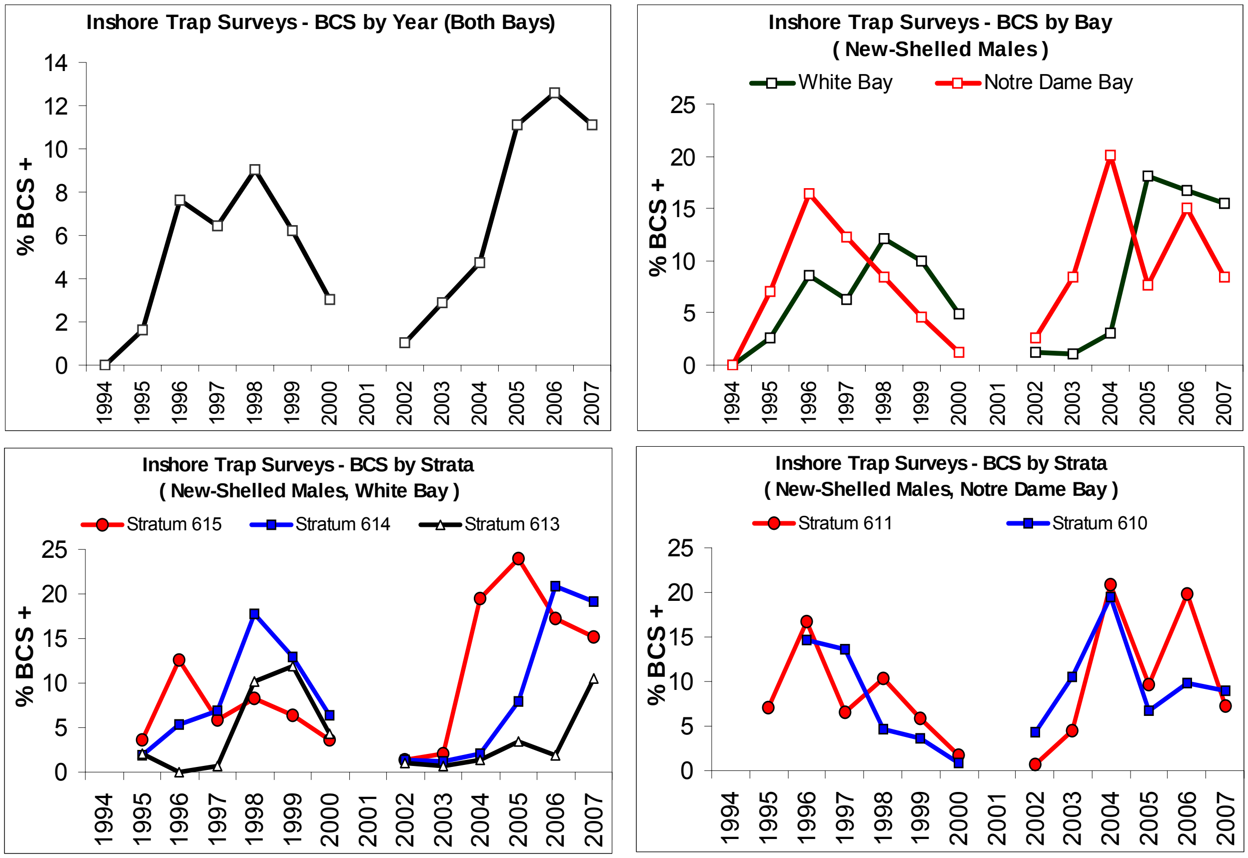


Figure 75. Prevalence of BCD in new-shelled males from Division 3K inshore trap surveys in White Bay and Notre Dame Bay for both bays combined (top left panel), by bay (top right panel), White Bay by stratum (bottom left panel) and Notre Dame Bay by stratum (bottom right panel).

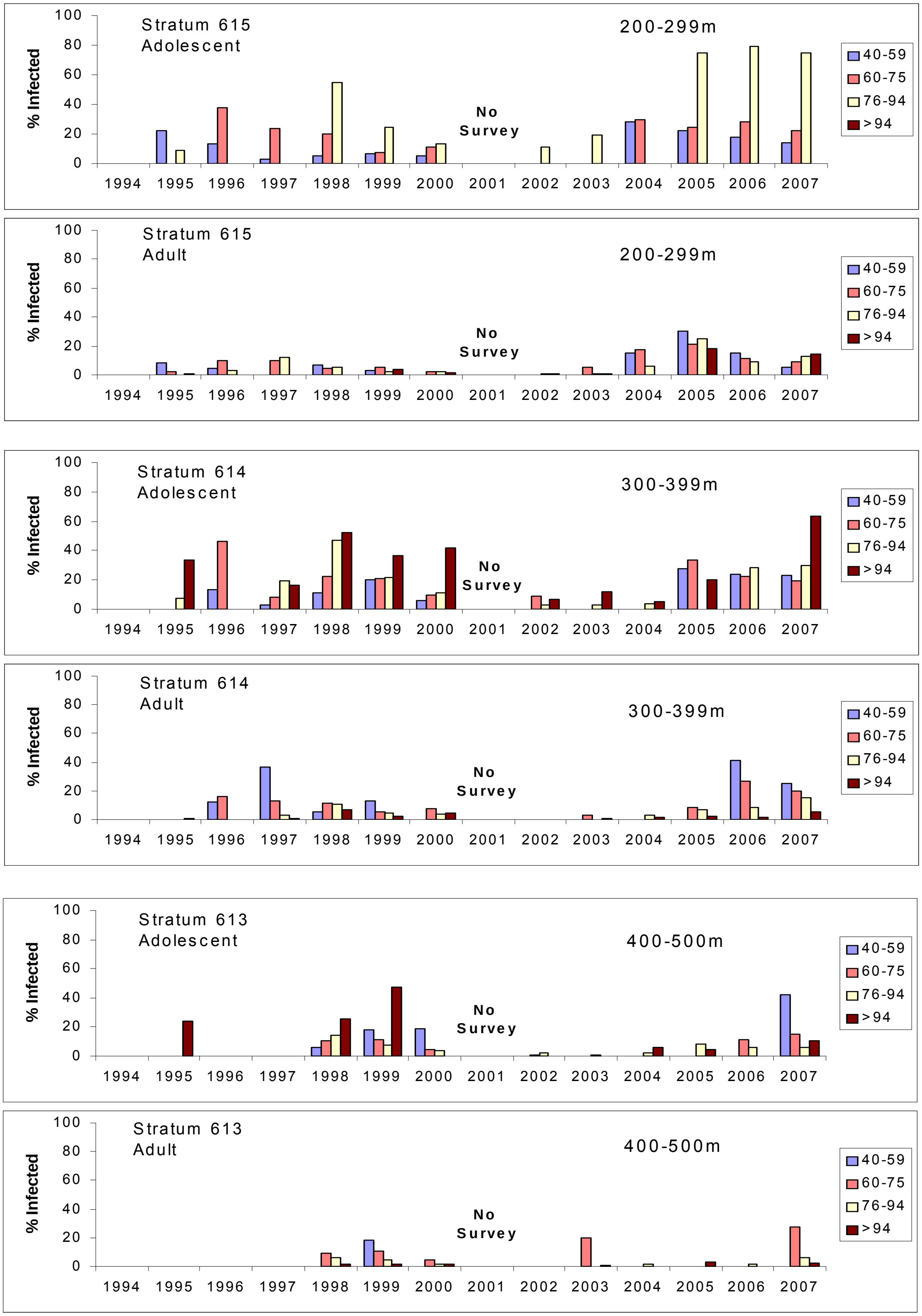


Figure 76. Incidence of BCD by stratum, year, and size group from trap surveys in White Bay; New-shelled males in adolescents (above) and adults (below).

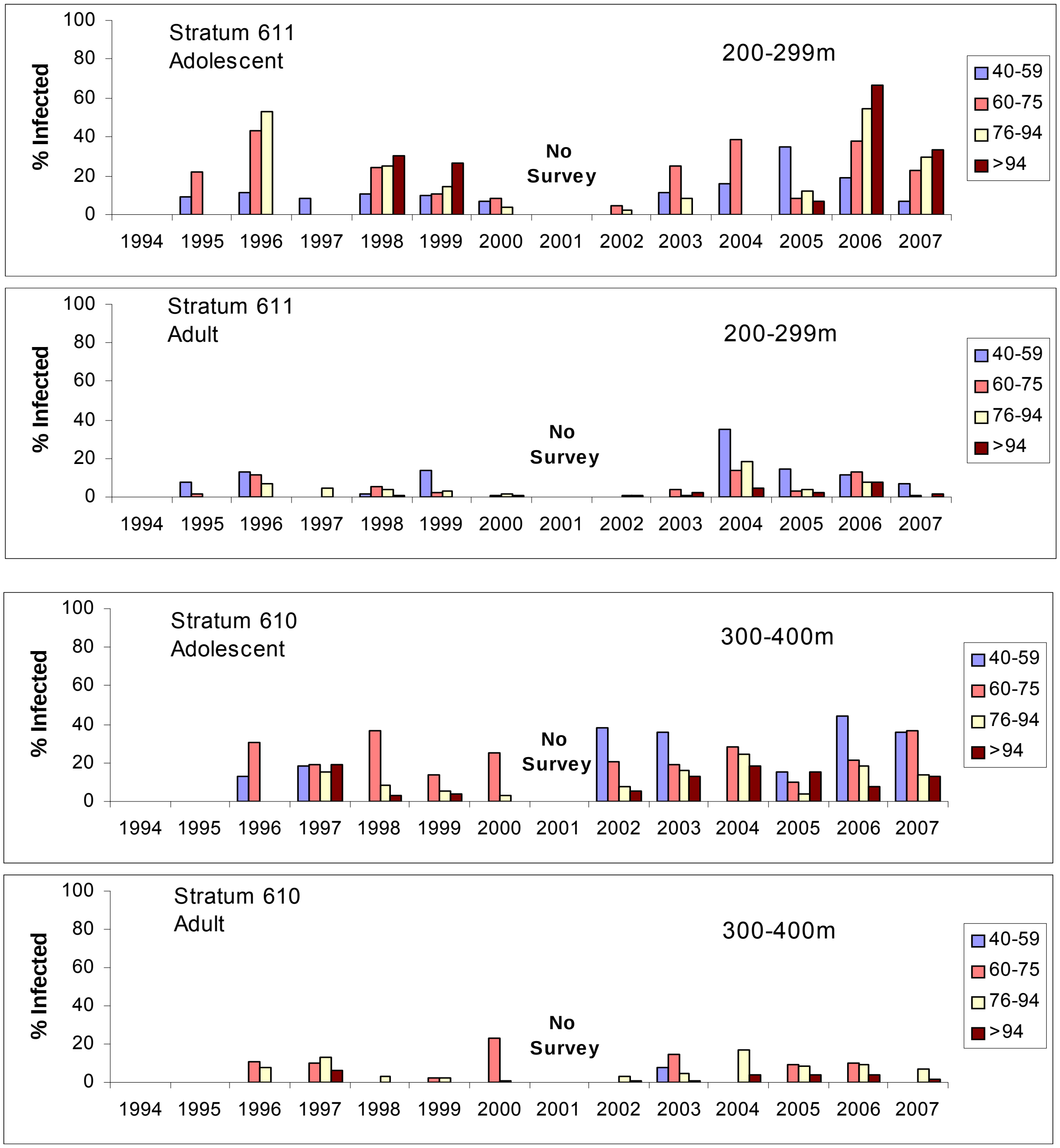
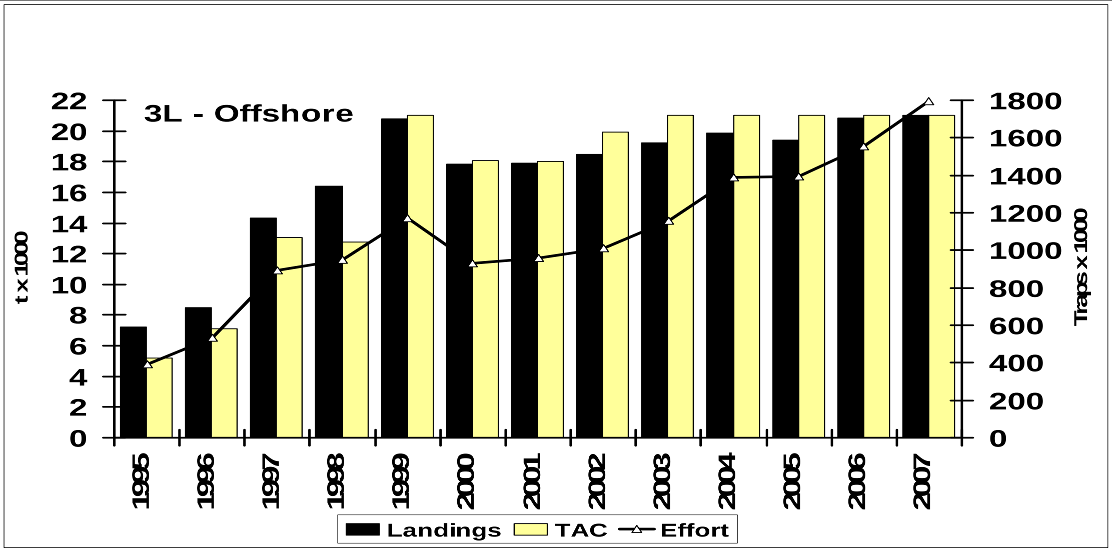


Figure 77. Incidence of BCD by stratum, year, and size group from trap surveys in Notre Dame Bay; New-shelled males in adolescents (above) and adults (below).



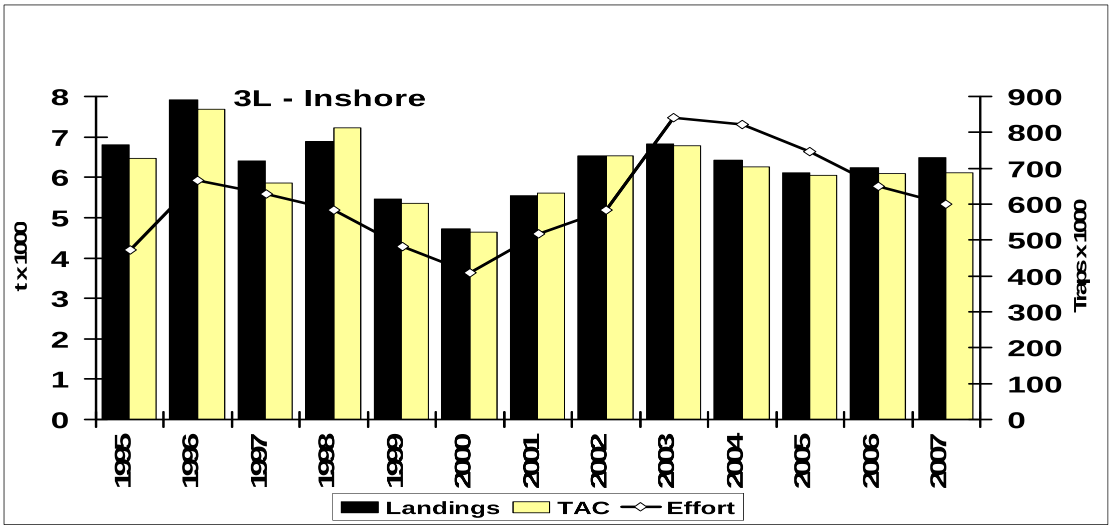


Figure 78. Trends in Division 3L landings, TAC, and fishing effort for the offshore (above) and inshore (below).

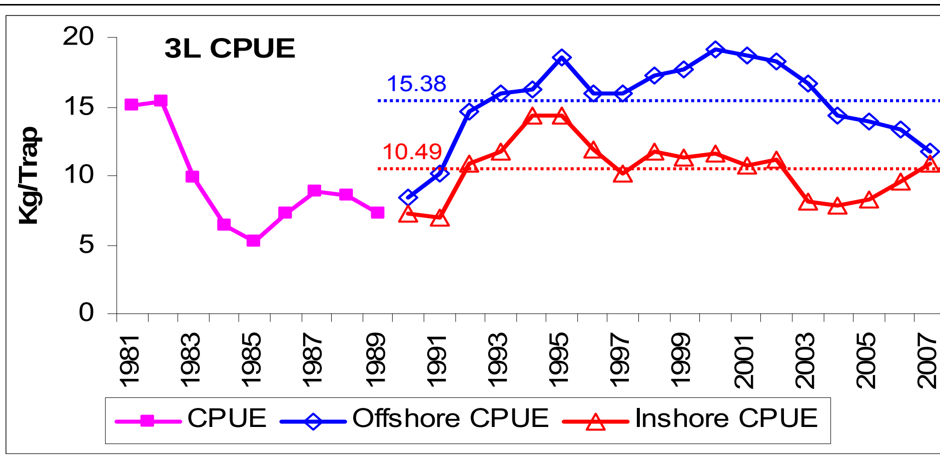


Figure 79. Trends in Division 3L offshore and inshore commercial CPUE in relation to their long-term averages (dotted lines).

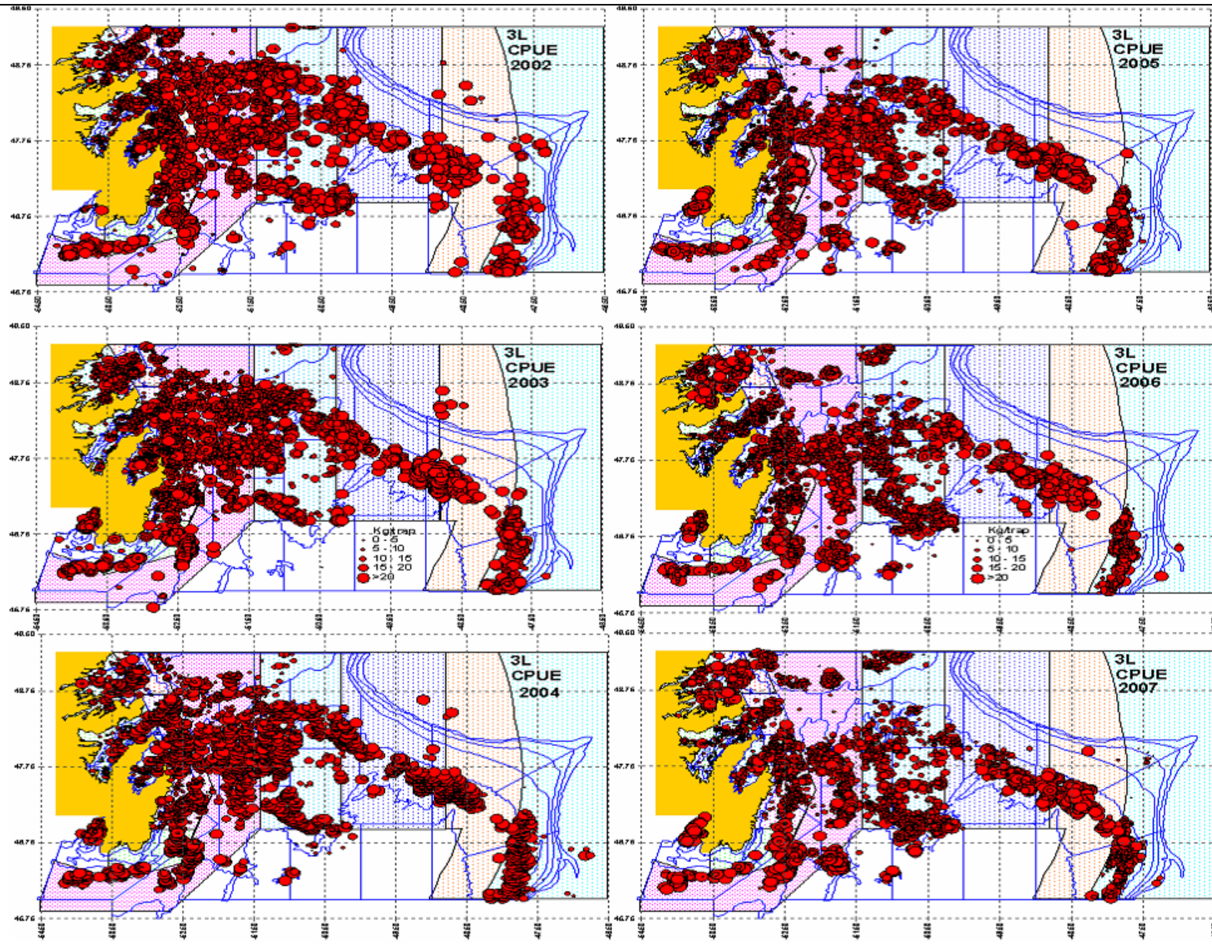


Figure 80. Spatial distribution of Division 3L commercial CPUE by year.

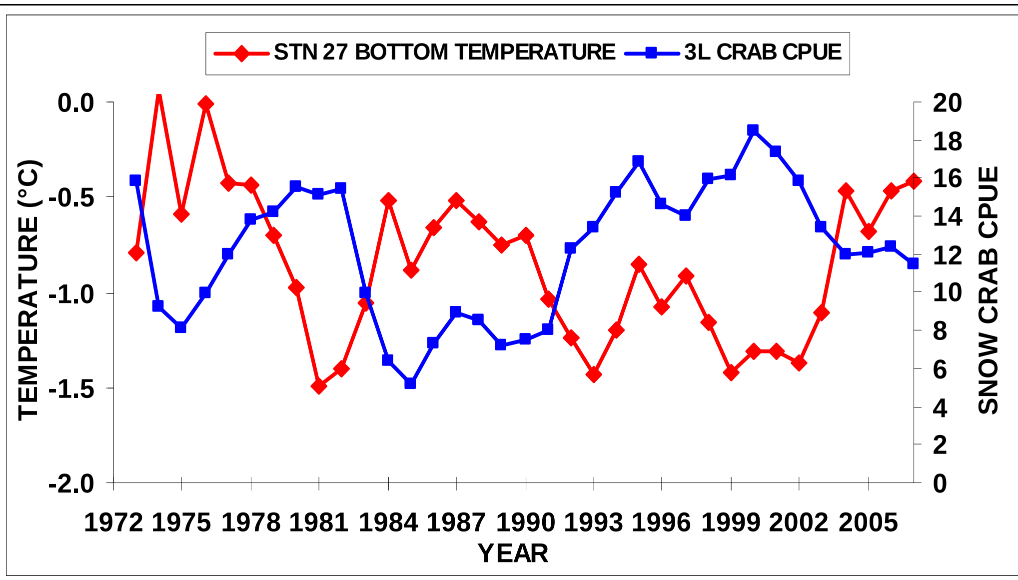


Figure 81. Trends in commercial CPUE in the Division 3L fishery (offshore and inshore combined) vs. bottom temperature at an eight year lag.

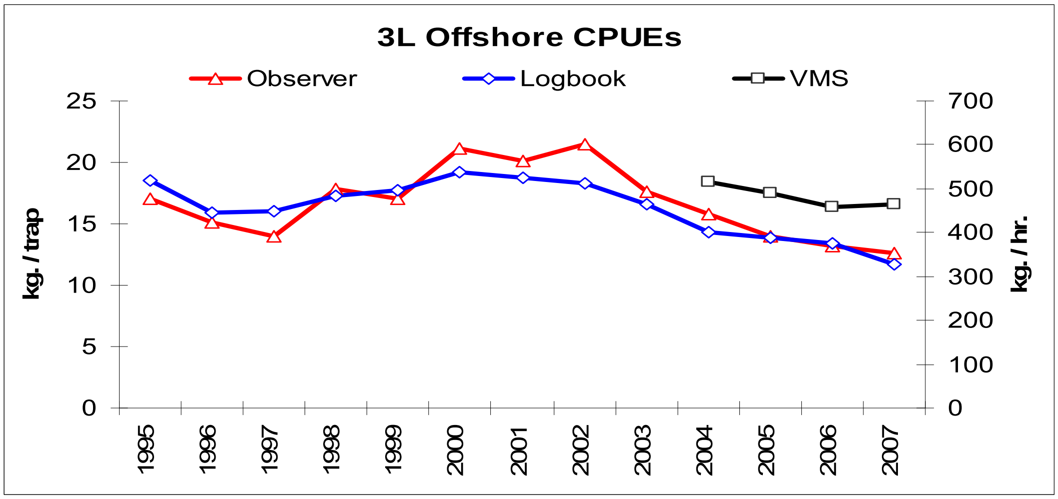


Figure 82. Trends in commercial logbook-based CPUE, observer-based CPUE and VMS-based CPUE in the Division 3L offshore fishery.

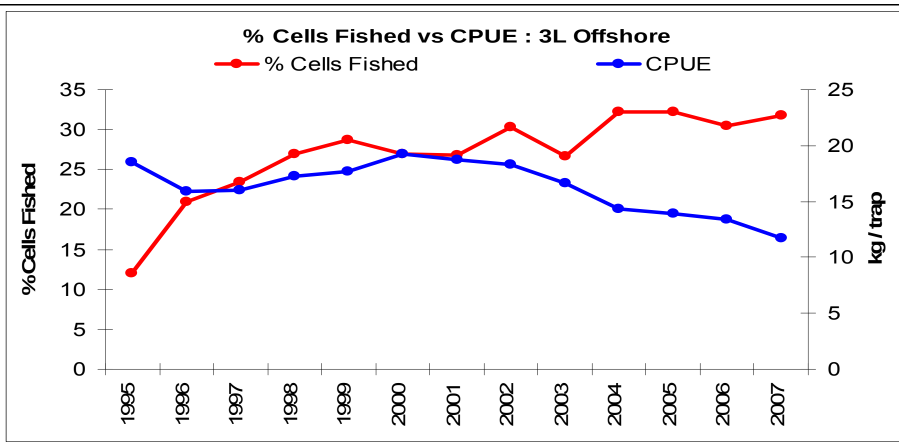


Figure 83.Trends in Division 3L offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

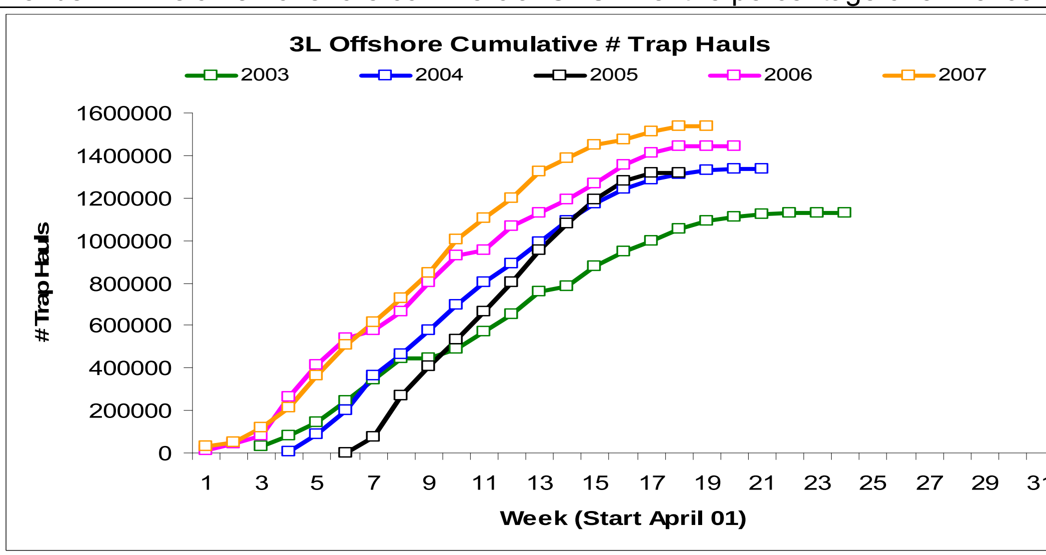


Figure 84. Seasonal trends in fishing effort for Division 3L offshore during 2003-07.

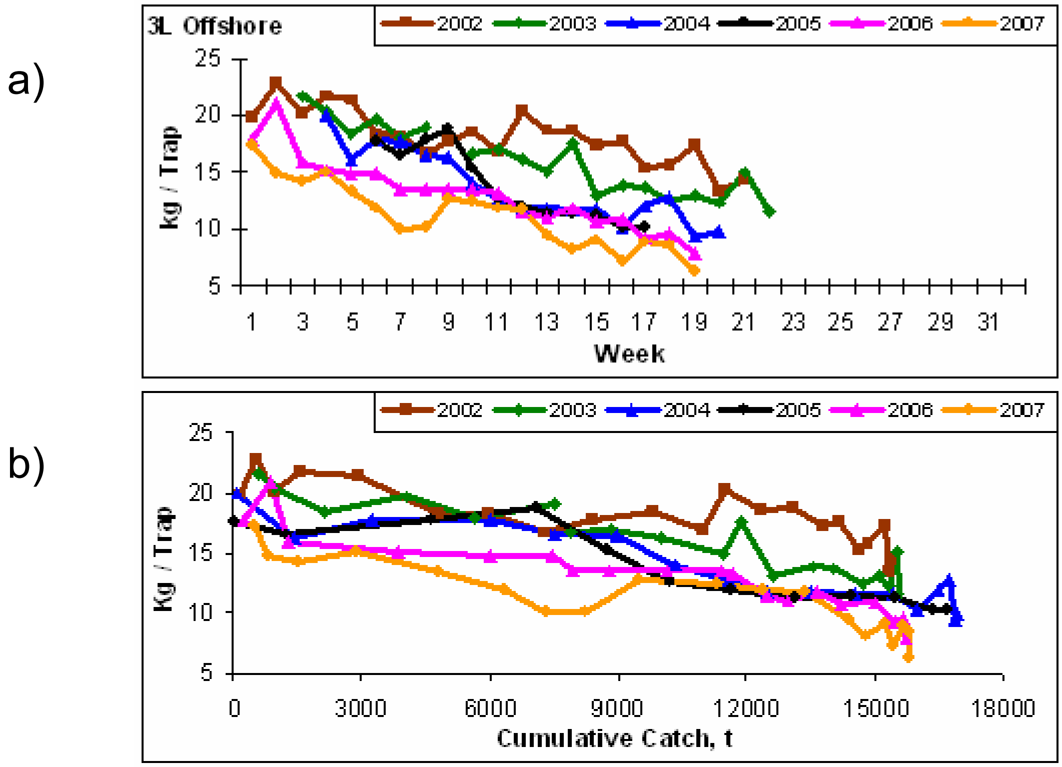


Figure 85. Seasonal trends in logbook-based CPUE for Division 3L offshore during 2002-07; (a) by week, and (b) in relation to cumulative catch.

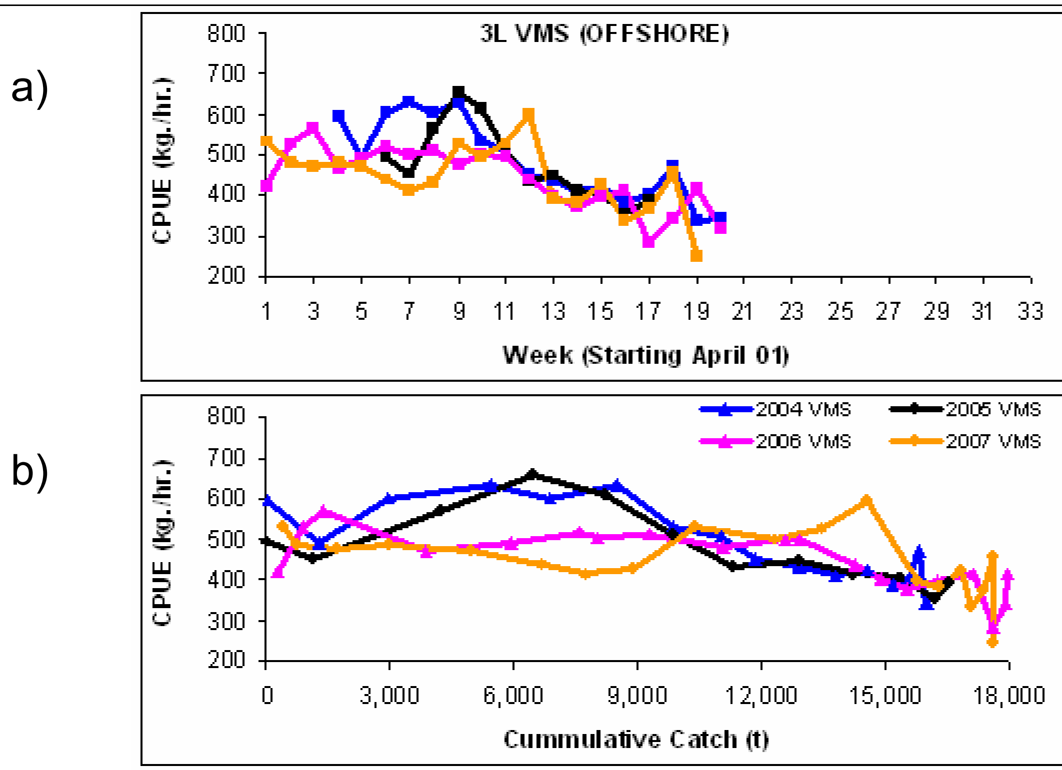


Figure 86. Seasonal trends in VMS-based CPUE for Division 3L offshore during 2002-07; (a) by week, and (b) in relation to cumulative catch.

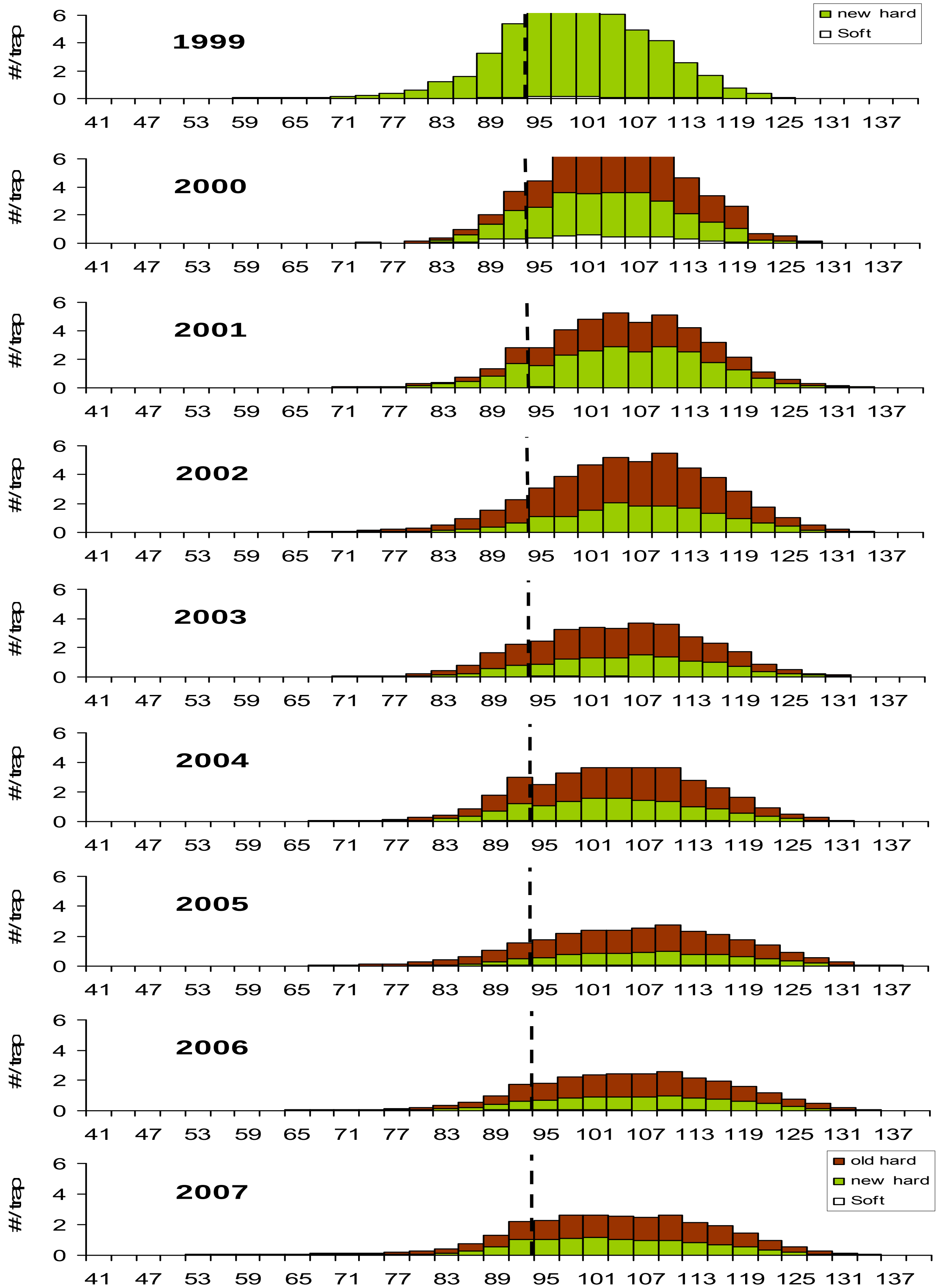
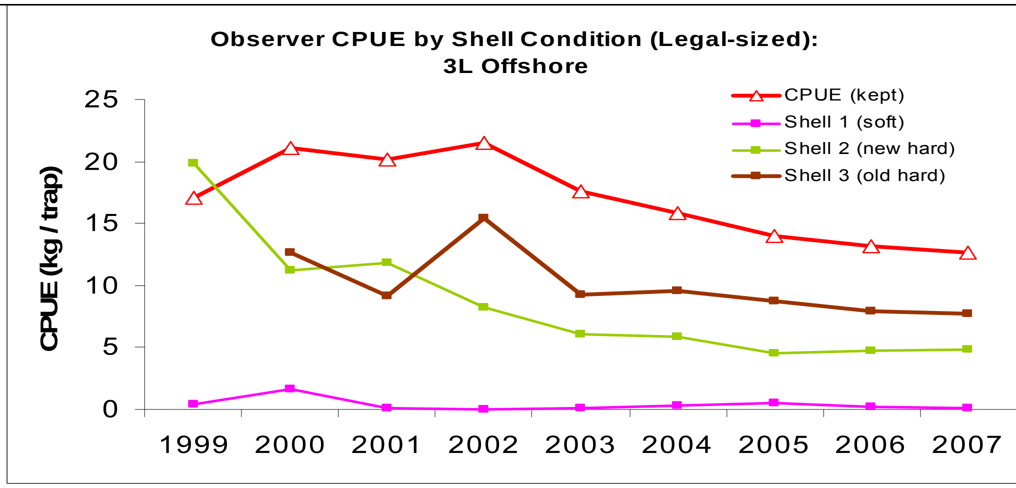


Figure 87. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Division 3L offshore. The vertical dashed line indicates the minimum legal size.

a)



b)

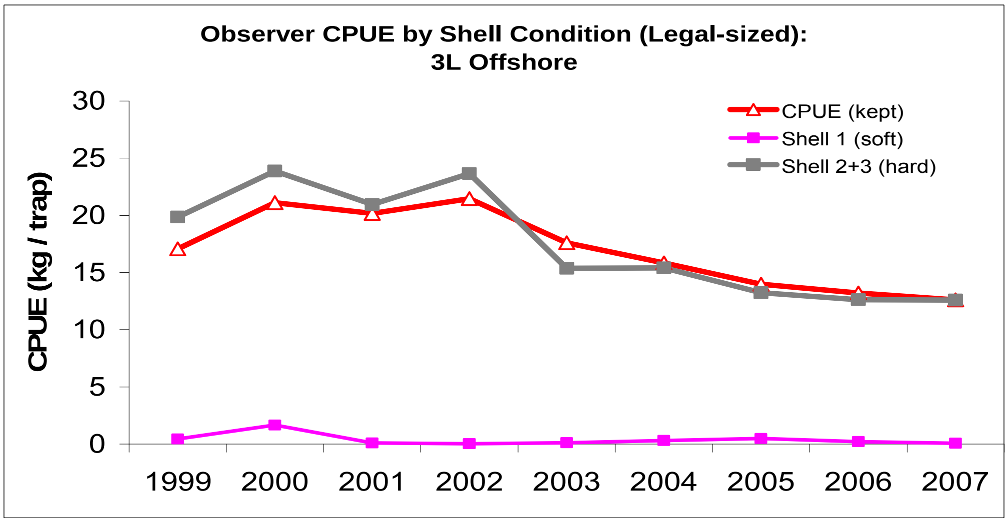


Figure 88. Trends in Division 3L offshore observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

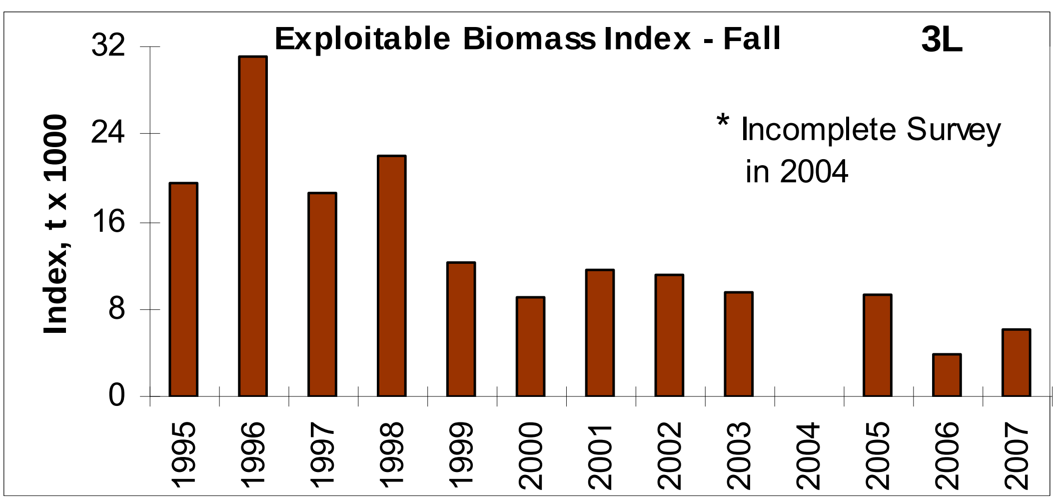


Figure 89. Trends in the Division 3L fall trawl survey exploitable biomass index.

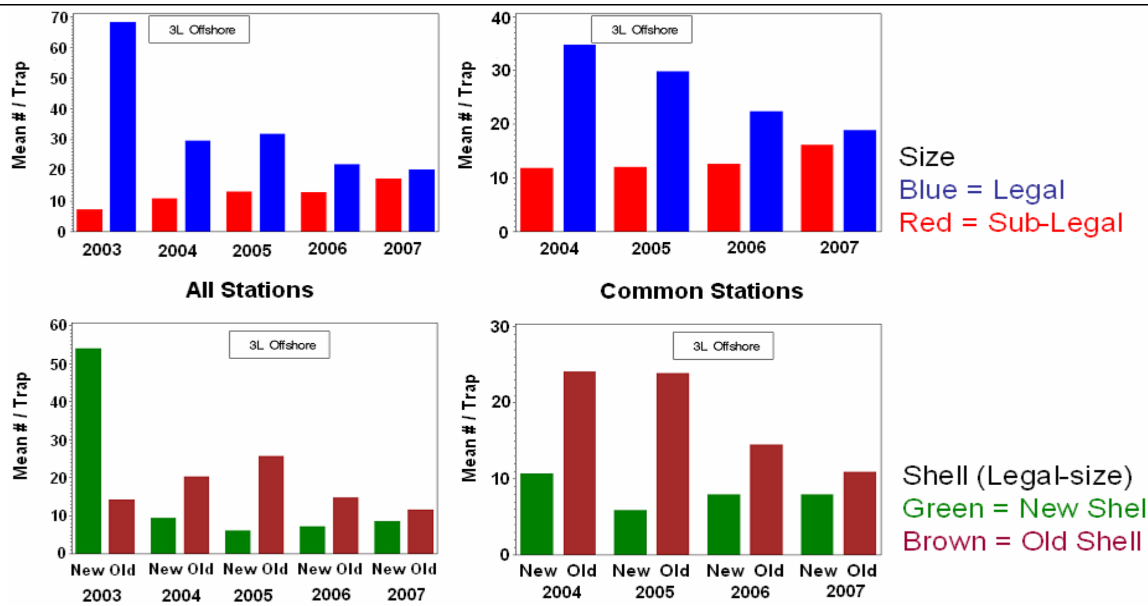


Figure 90. Trends in CPUE by size group (above) and shell condition for legal-sized crabs (below) from industry-DFO collaborative post-season trap surveys for Division 3L offshore from all stations (left) and common stations (right).

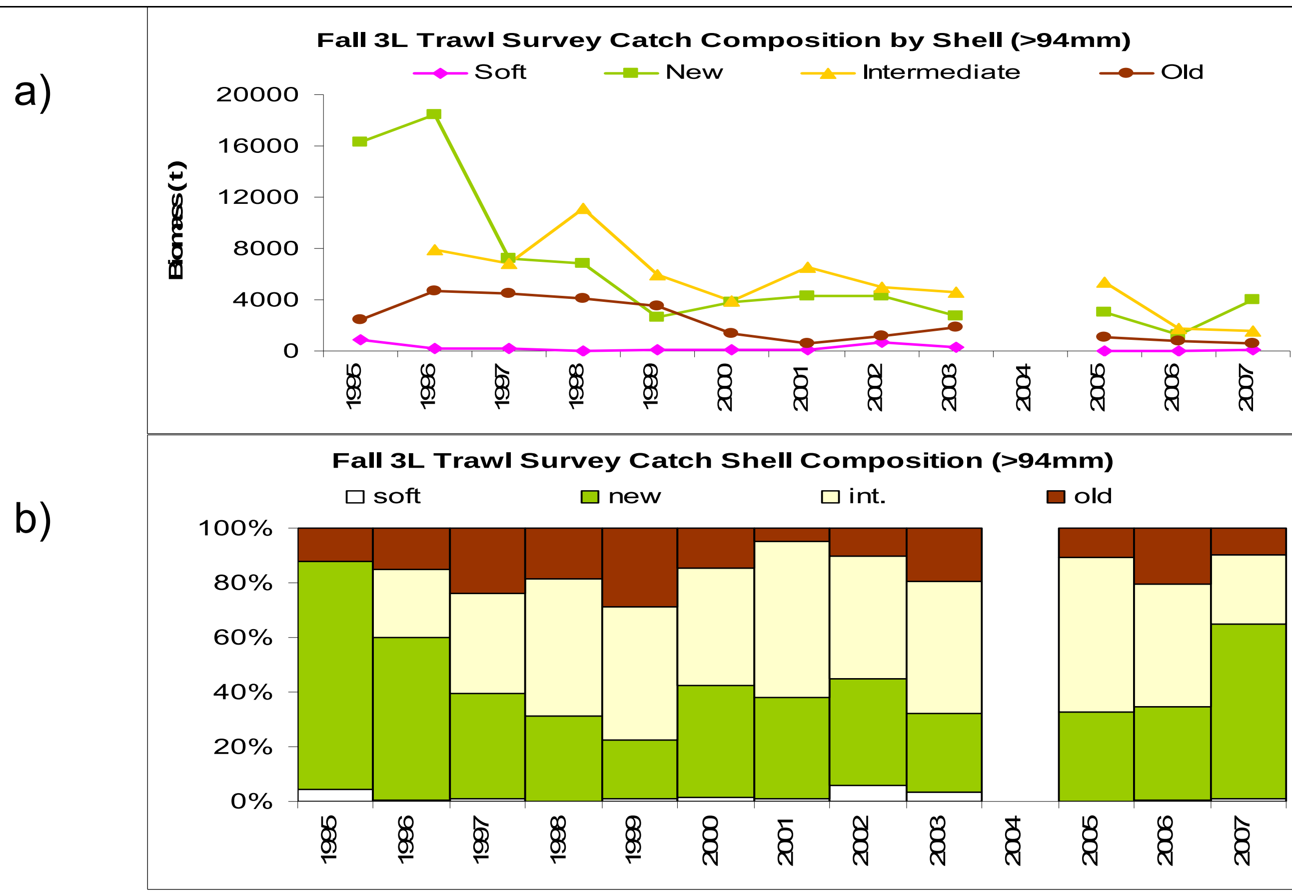


Figure 91. Trends, by shell condition, in exploitable males for Division 3L offshore from fall trawl surveys for; a) biomass, and (b) percentages of the total catch.

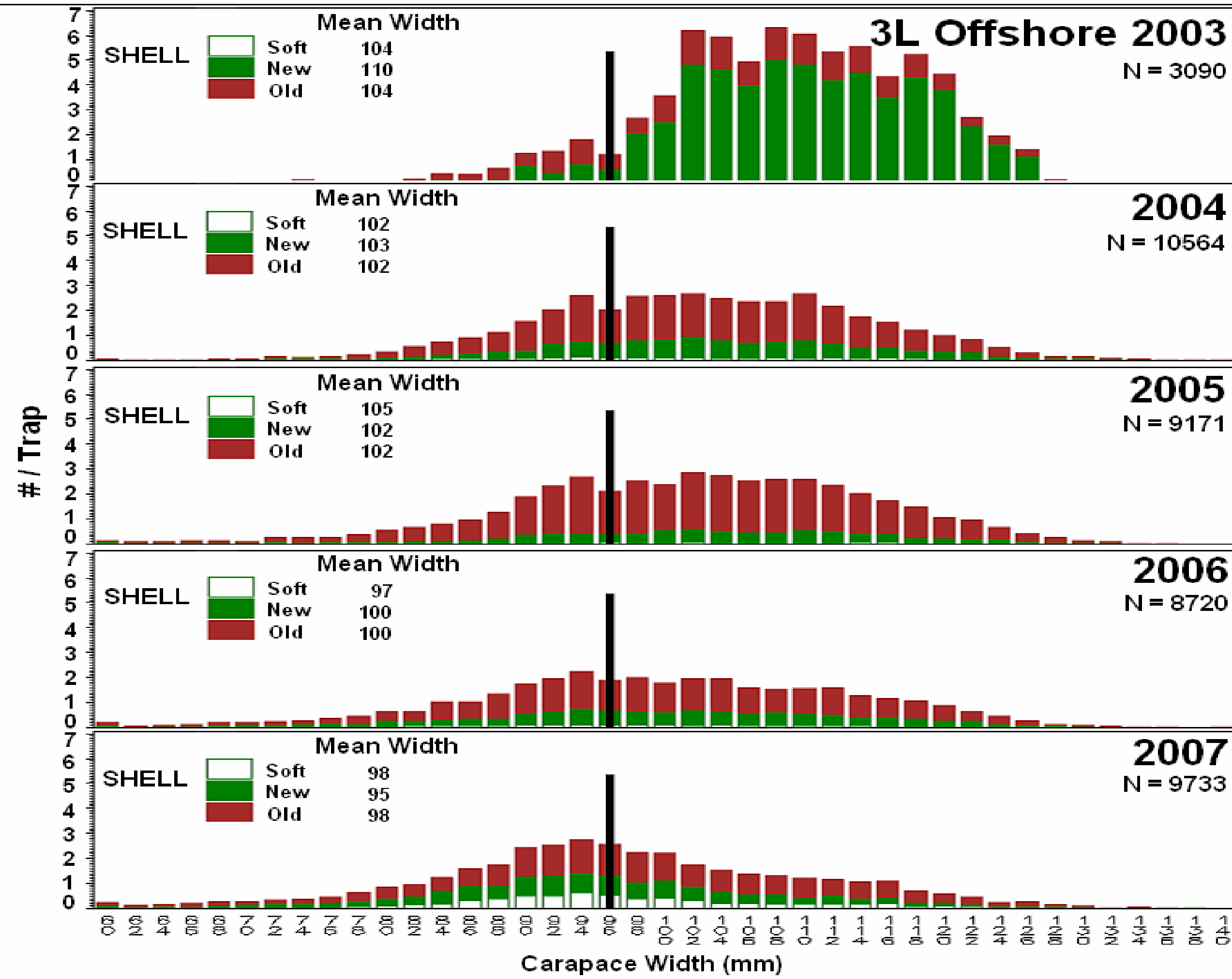


Figure 92. Trends in male carapace width distributions from industry-DFO post-season trap surveys for Division 3K offshore (all stations). The vertical solid line indicates the minimum legal size.

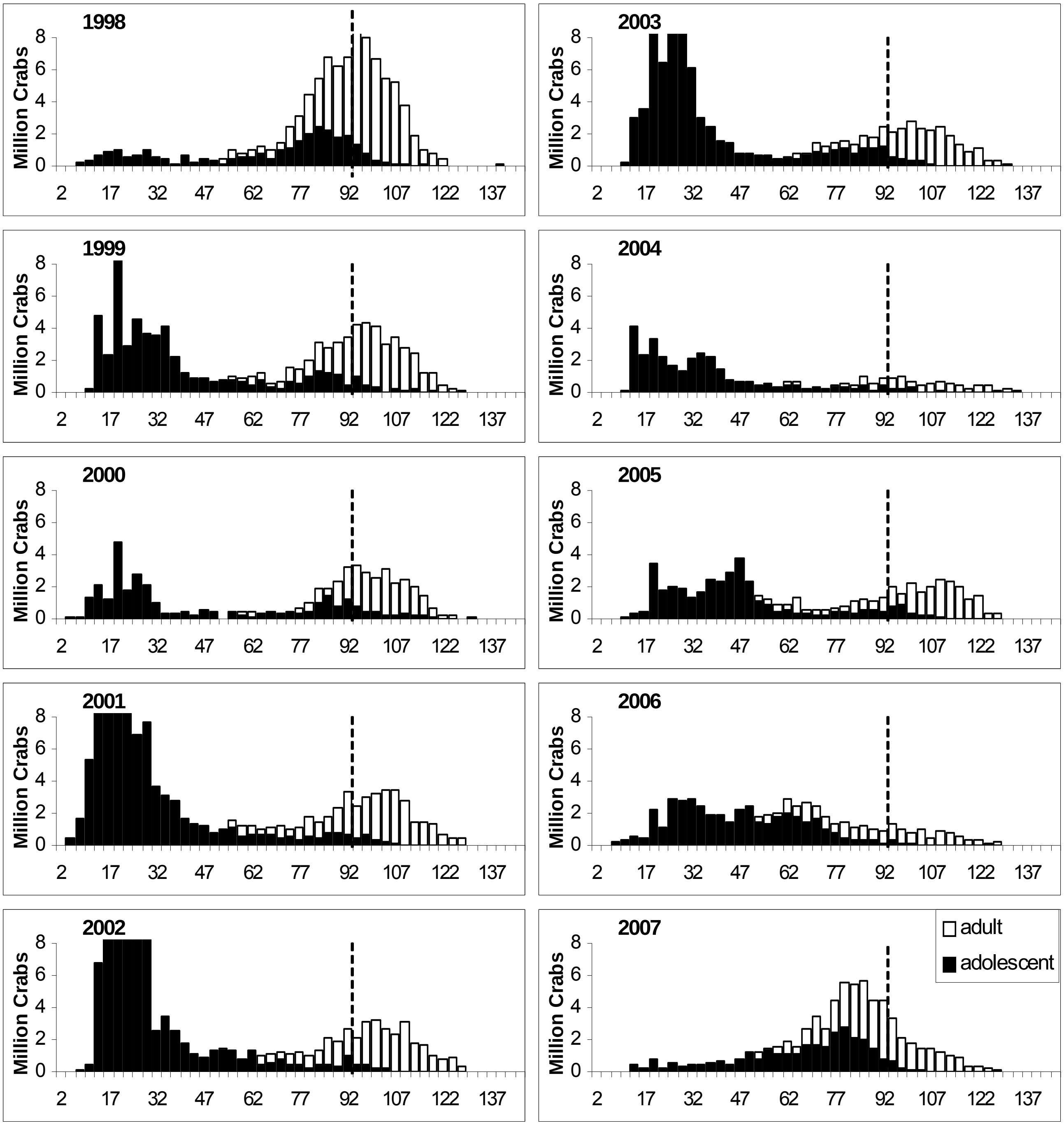


Figure 93. Distribution of abundance (index) by carapace width for Division 3L juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line.

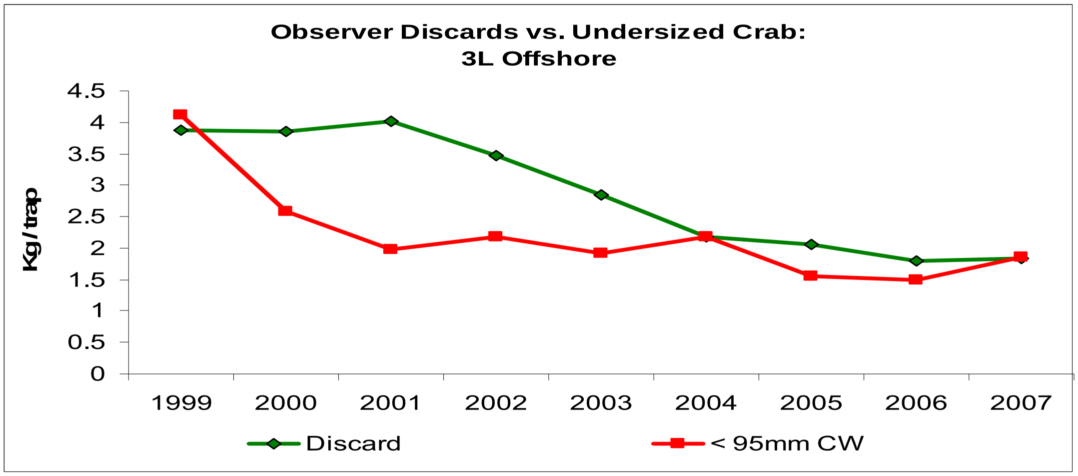


Figure 94. Trends in Division 3L offshore observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

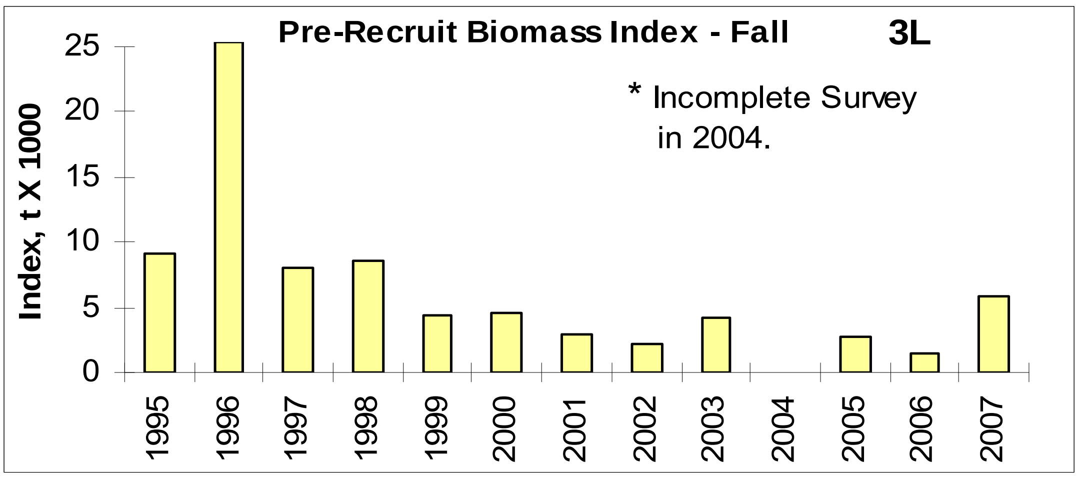


Figure 95. Trends in the Division 3L fall trawl survey pre-recruit biomass index.

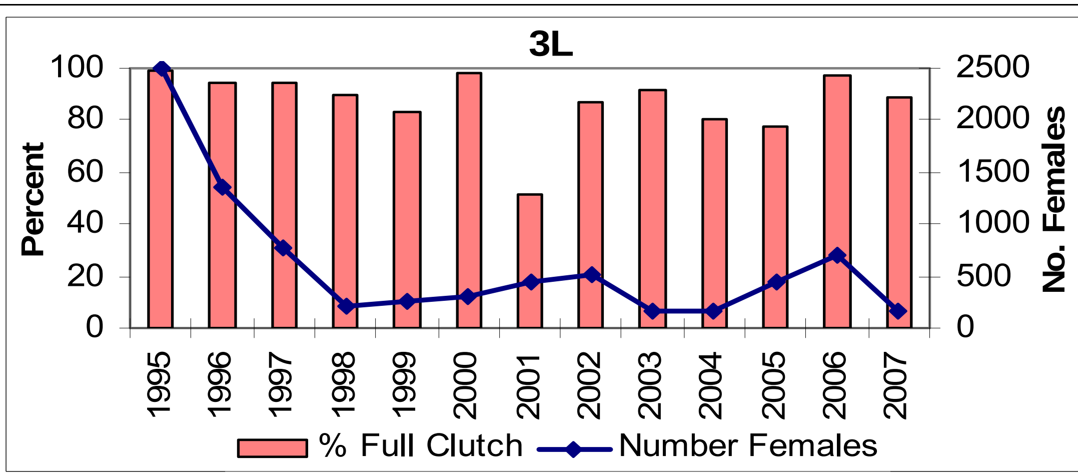


Figure 96. Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 3L from fall multi-species surveys.

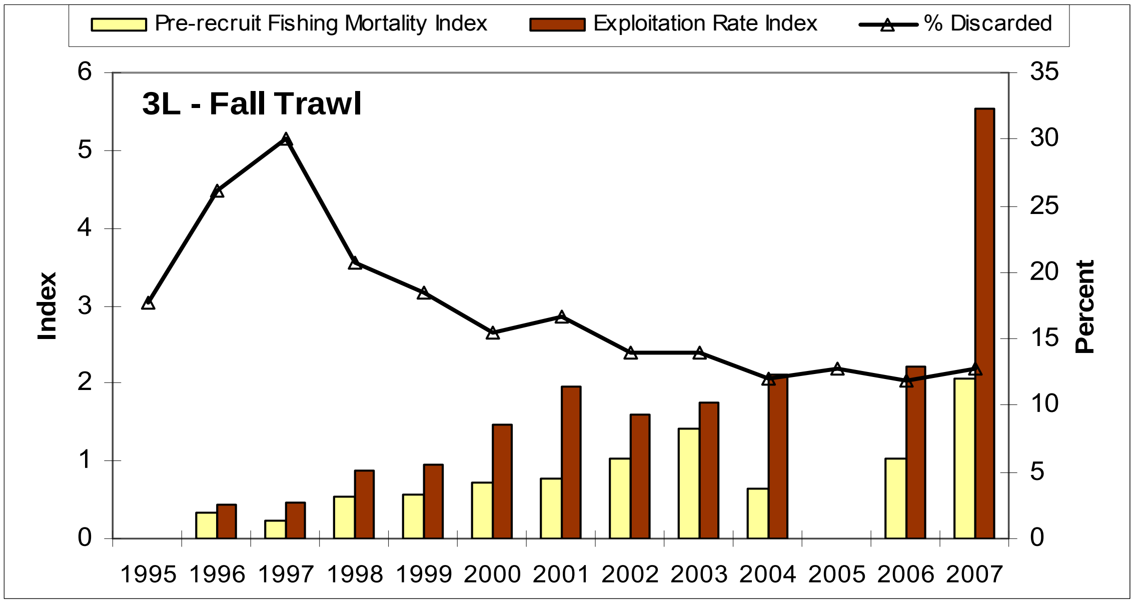


Figure 97. Trends in Division 3L offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery (No 2005 exploitation rate or pre-recruit fishing mortality indices because of an incomplete 2004 survey.)

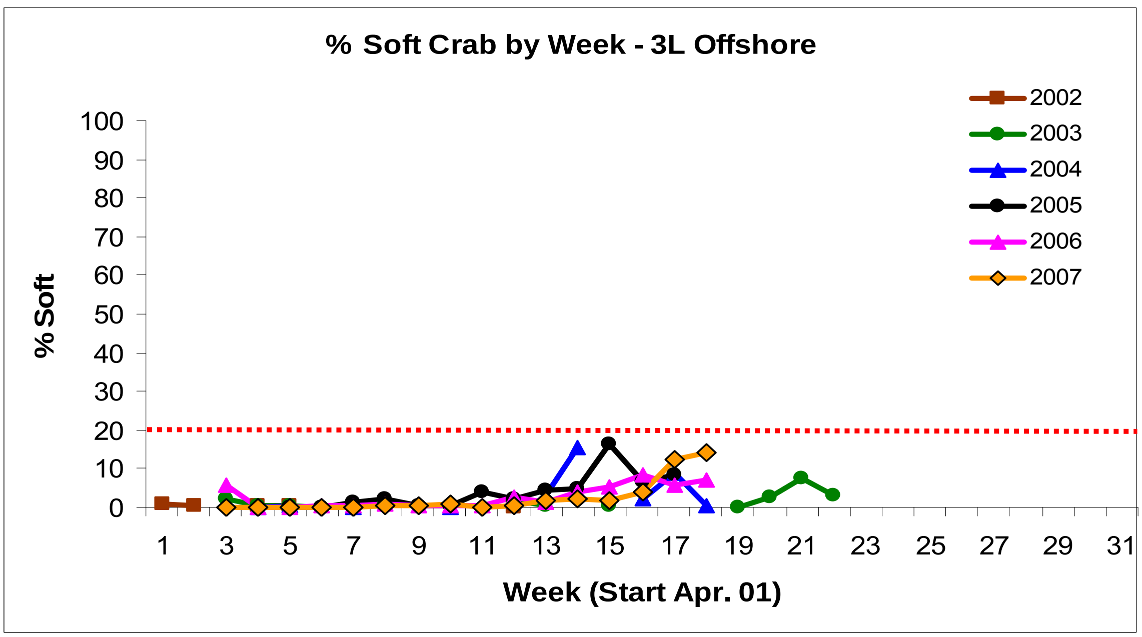


Figure 98. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Division 3L offshore fishery that are soft-shelled, by year (2002-07), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed.)

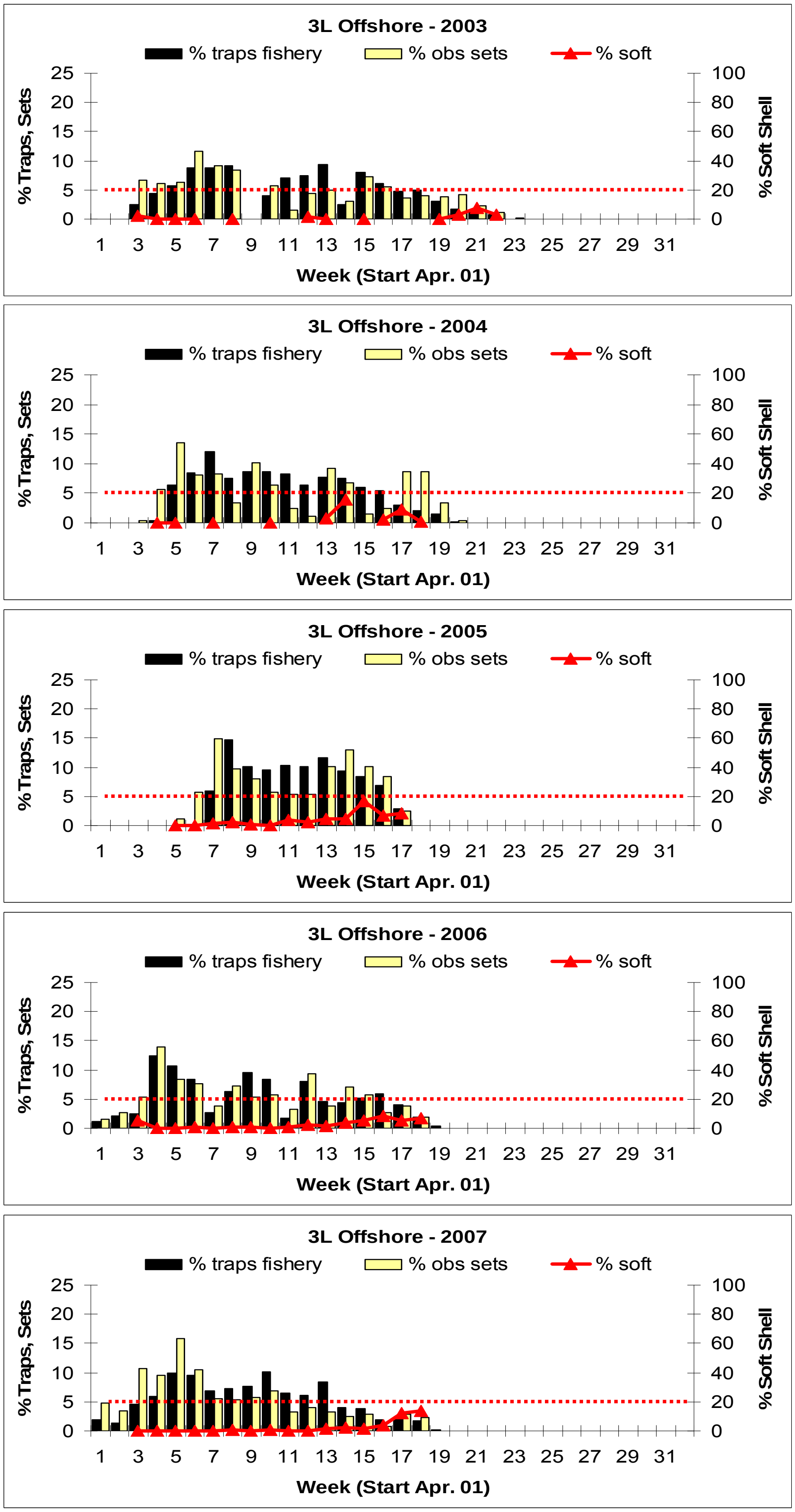


Figure 99. Seasonal trends in Division 3L offshore distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2003-2007. (Sample sizes of <10 observed sets/week removed.)

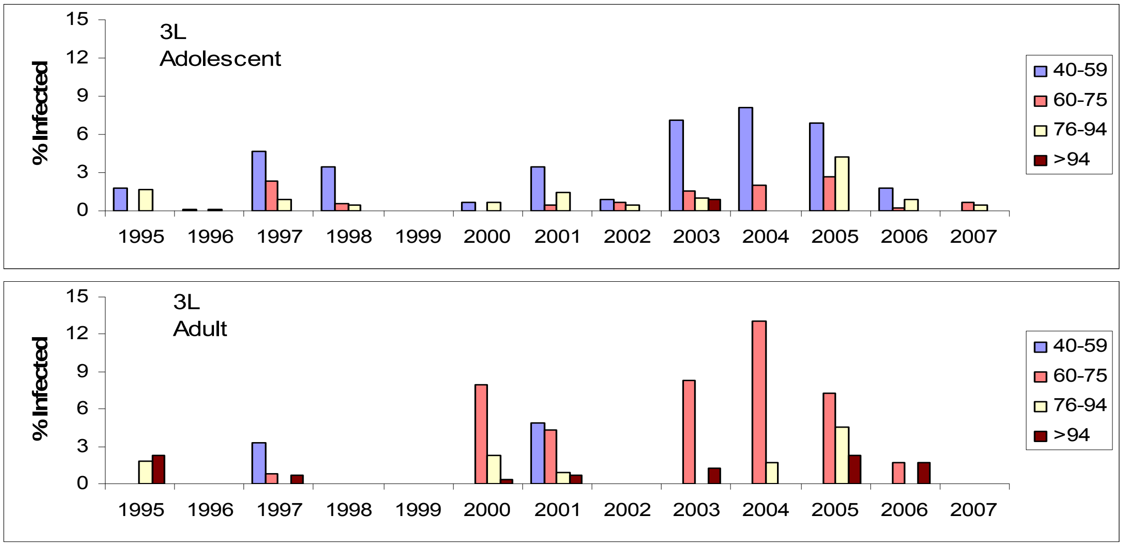


Figure 100. Trends in prevalence of BCD in new-shelled adolescents (above) and adults (below) by male size group from Division 3L fall trawl surveys.

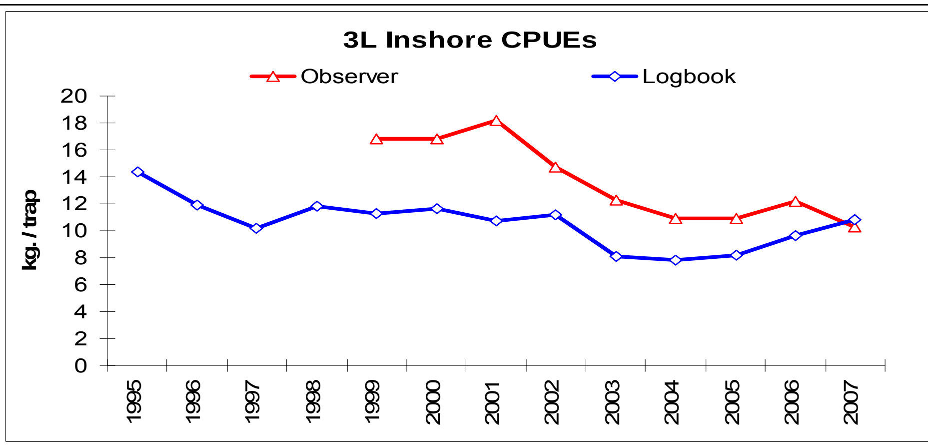


Figure 101. Trends in commercial logbook-based CPUE and observer-based CPUE in the Division 3L inshore fishery.

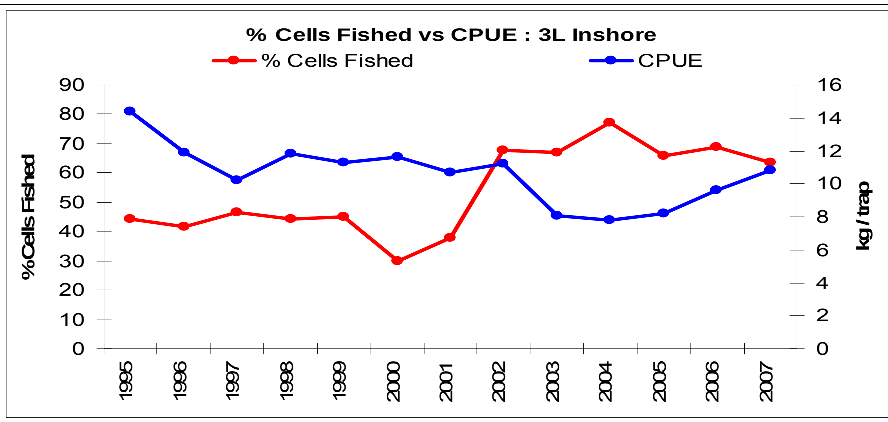


Figure 102. Trends in Division 3L inshore commercial CPUE vs. the percentage of 5’ x 5’ cells fished.

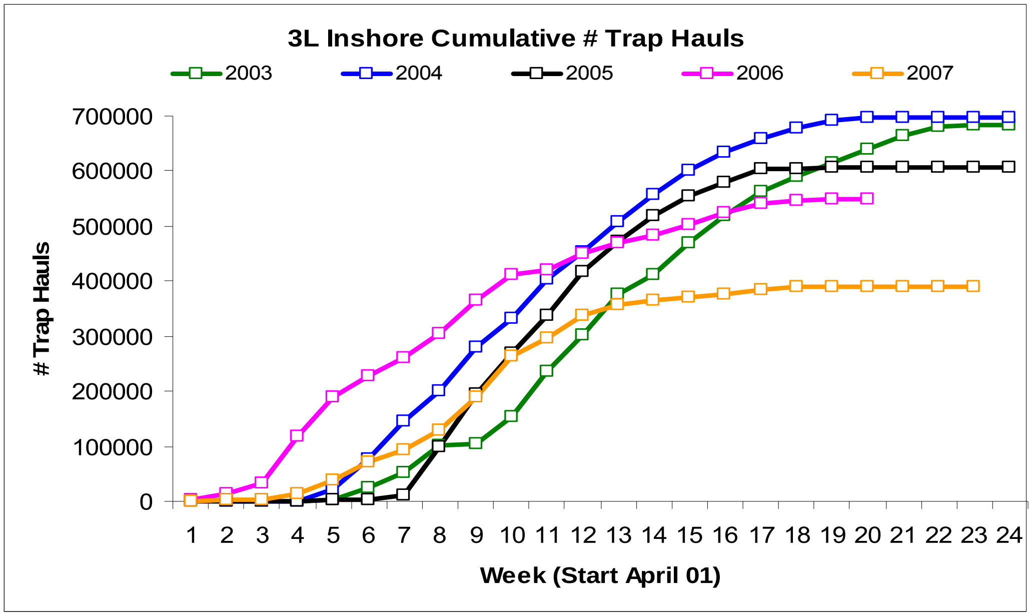


Figure 103. Seasonal trends in fishing effort for Division 3L inshore during 2003-07.

a)

b)

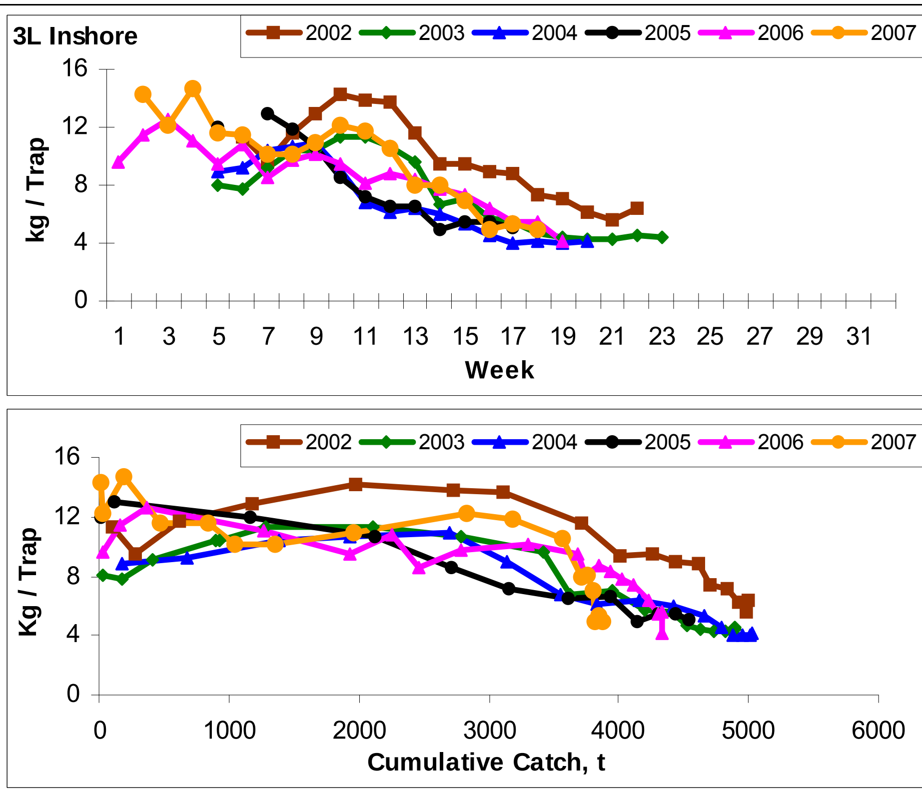


Figure 104. Seasonal trends in logbook-based CPUE for Division 3L inshore during 2002-07; (a) by week, and (b) in relation to cumulative catch.

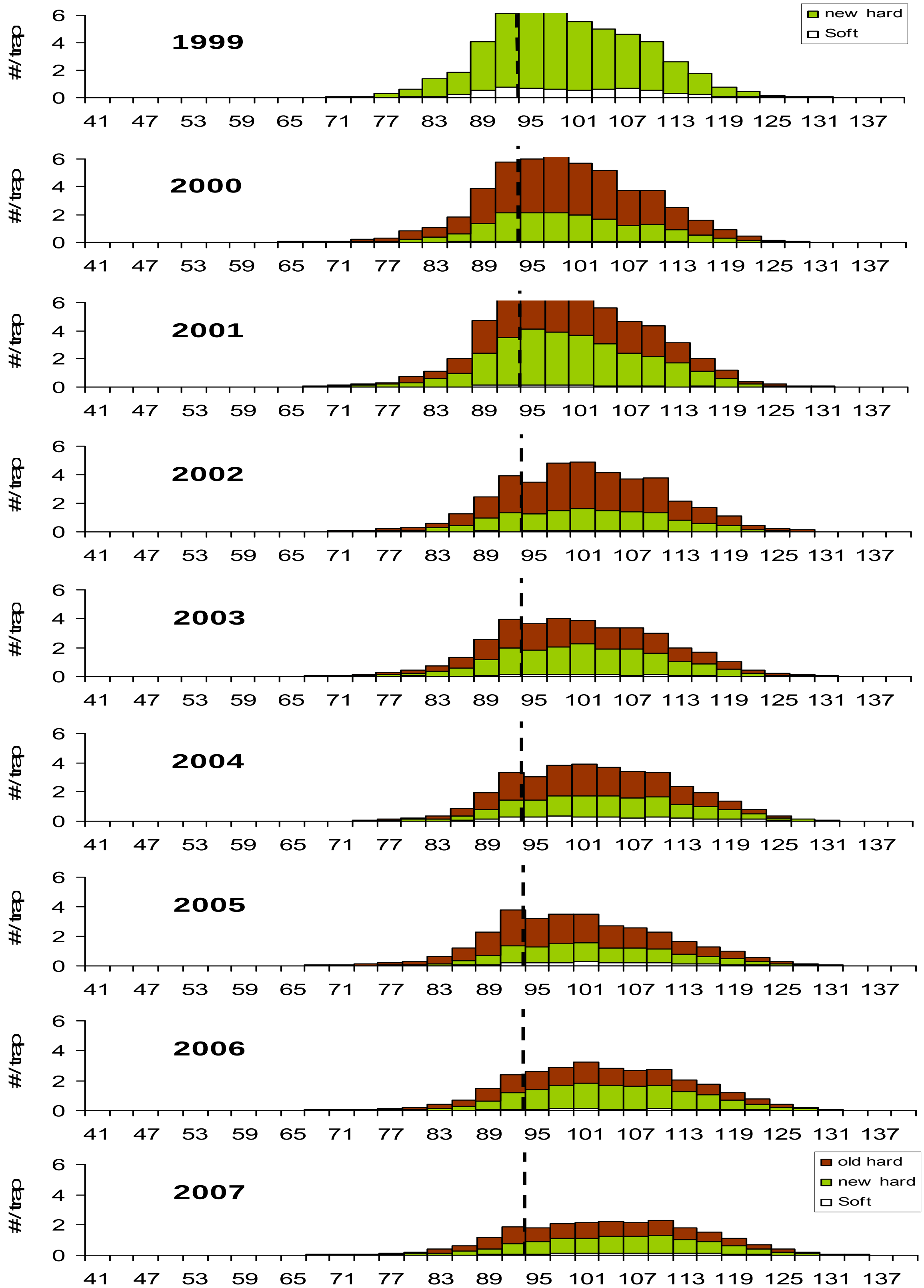
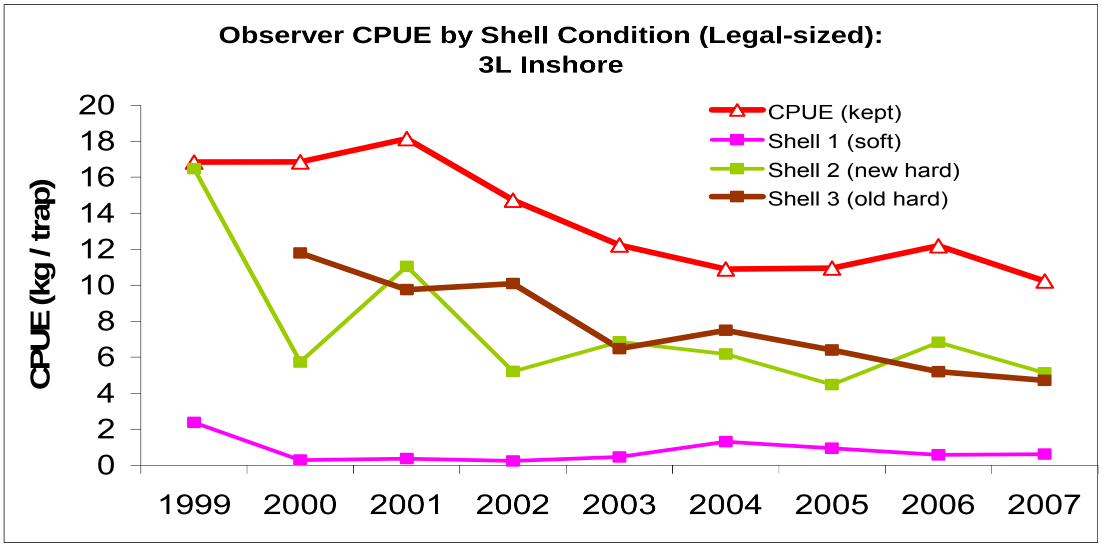


Figure 105. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Division 3L inshore. The vertical dashed line indicates the minimum legal size.

a)



b)

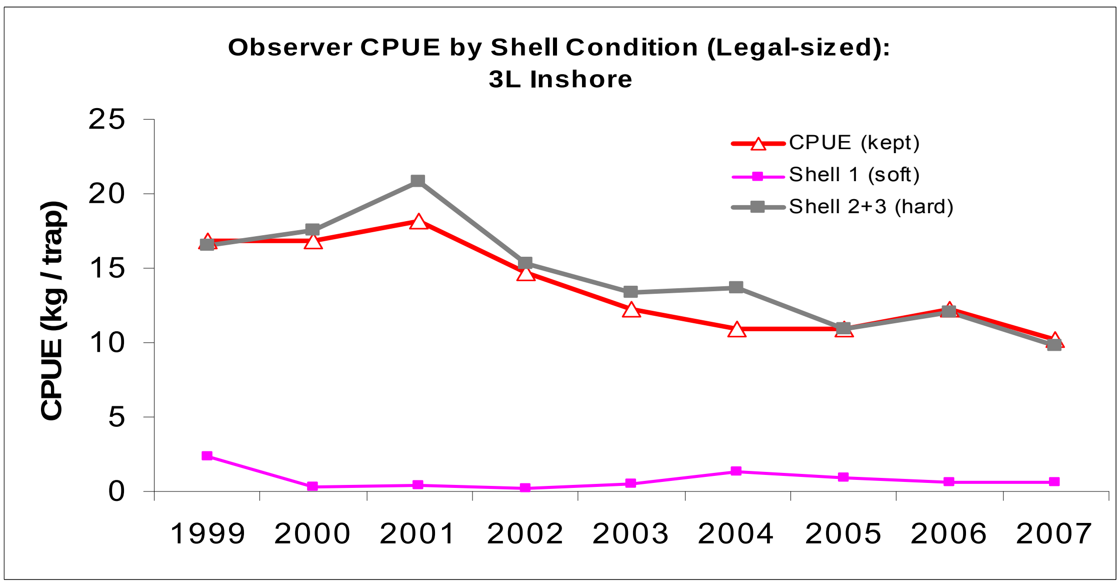


Figure 106. Trends in Division 3L inshore observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

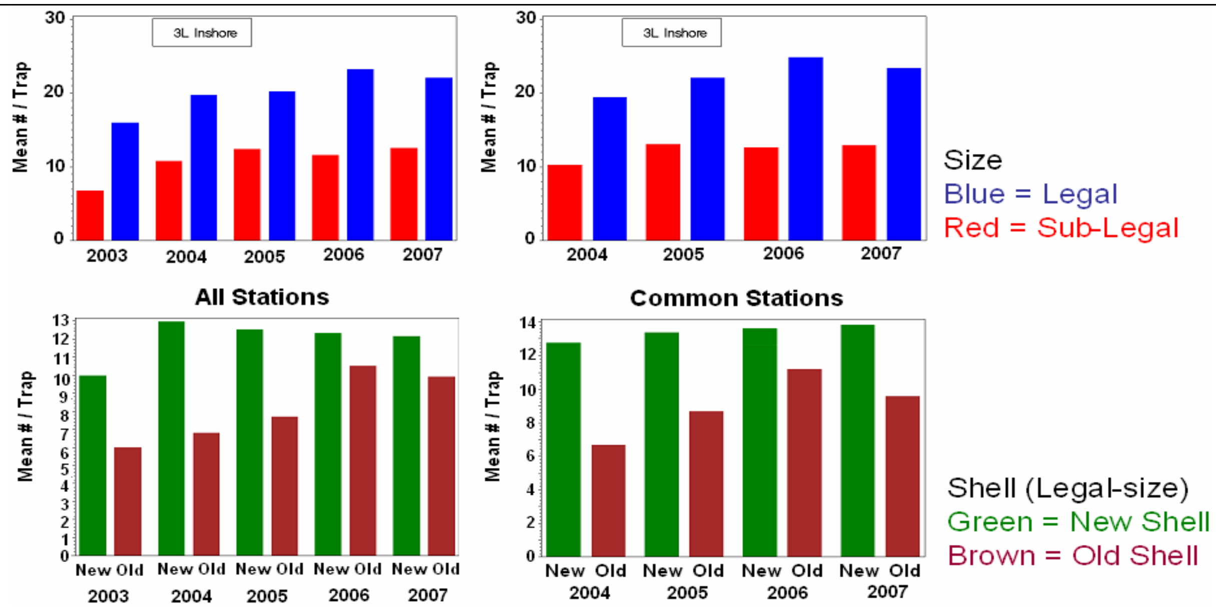


Figure 107. Trends in CPUE for size composition (above) and shell condition (below) from industry-DFO collaborative post-season trap surveys for Division 3L inshore from all stations (left) and common stations (right).

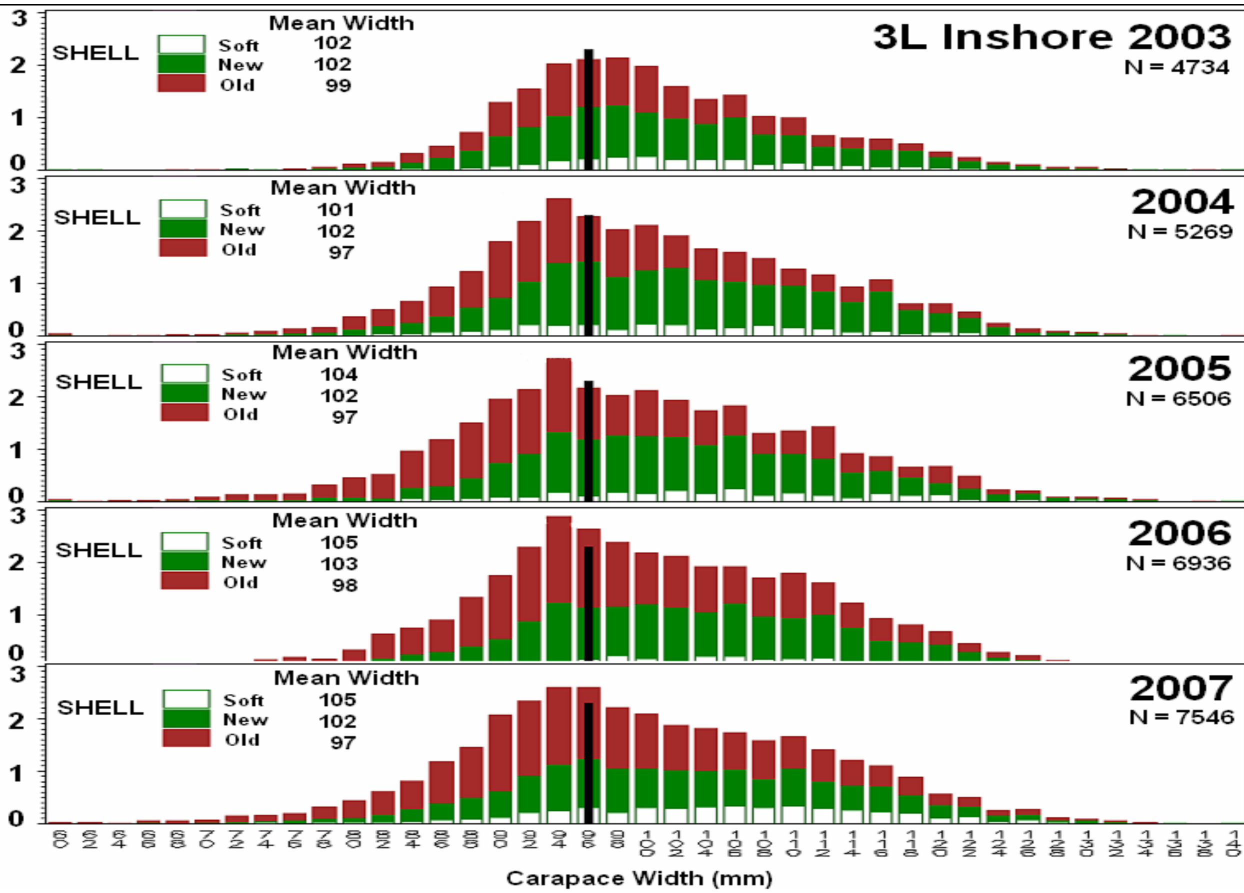


Figure 108. Trends in male carapace width distributions from industry-DFO post-season trap surveys for Division 3L inshore.

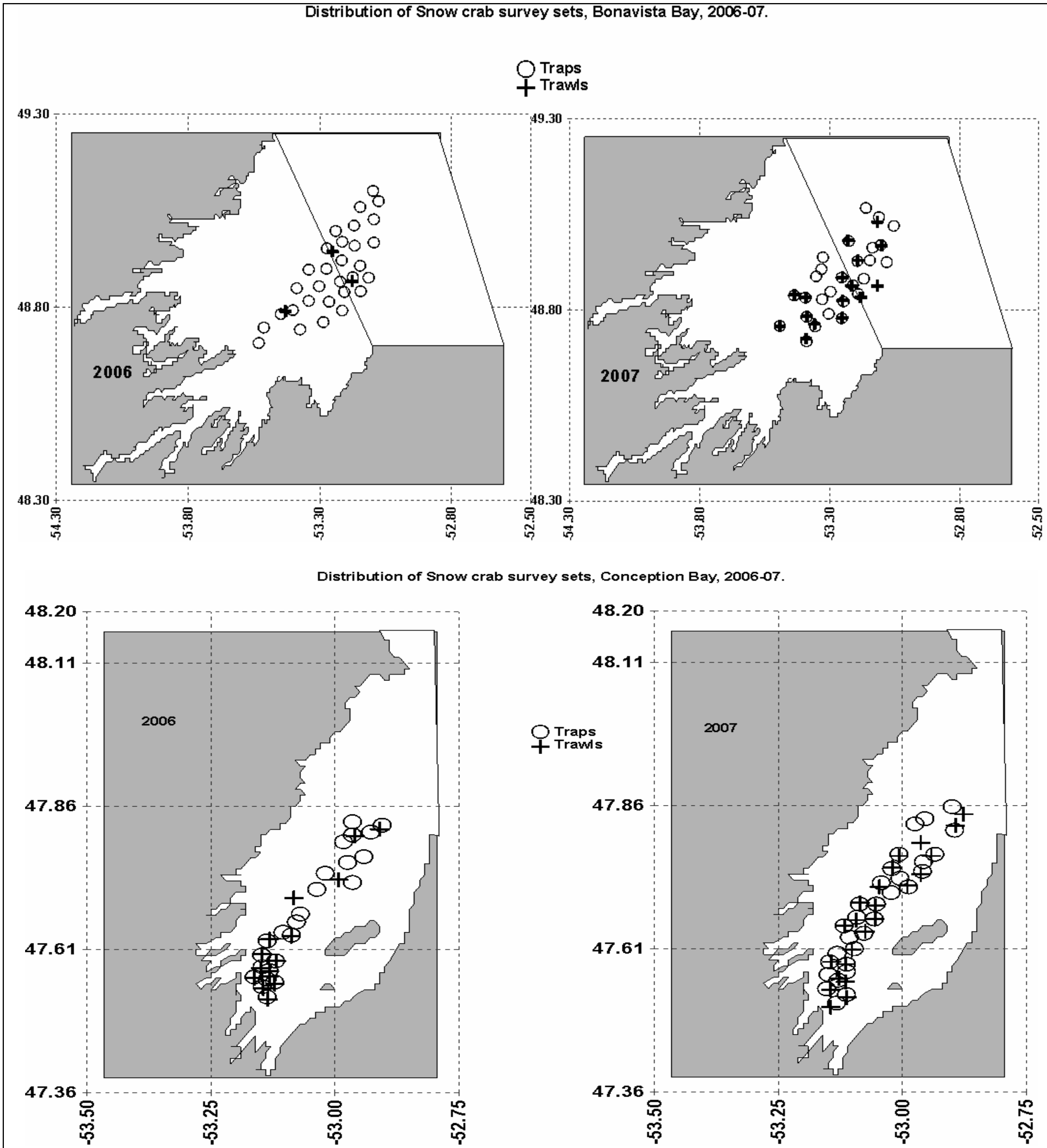


Figure 109. Location maps showing distribution of trap and trawl sets for inshore Division 3L surveys during summer in Bonavista Bay (top panels, CMA 5A – Fig. 1) and fall in Conception Bay (bottom panels, CMA 6B – Fig. 1) during 2006 and 2007.

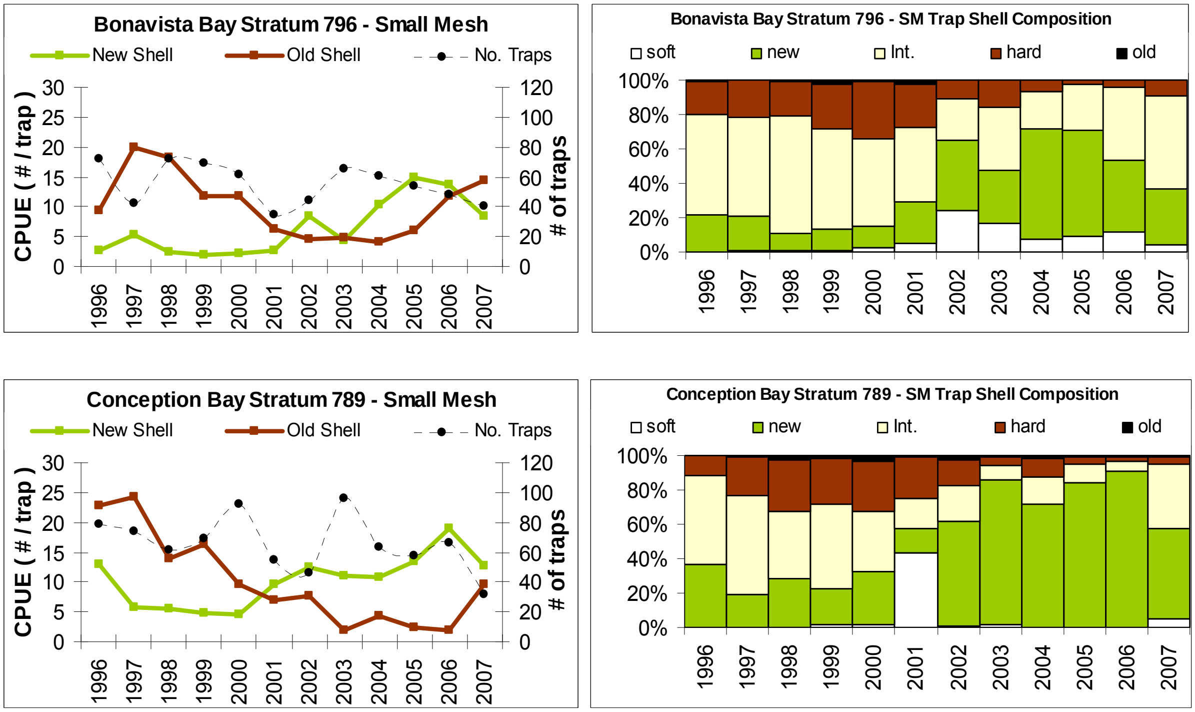


Figure 110a. Trends from small-mesh traps in shell condition of catches by stratum from inshore Division 3L trap surveys in Bonavista Bay (top panels) and Conception Bay (bottom panels), 1994-2007.

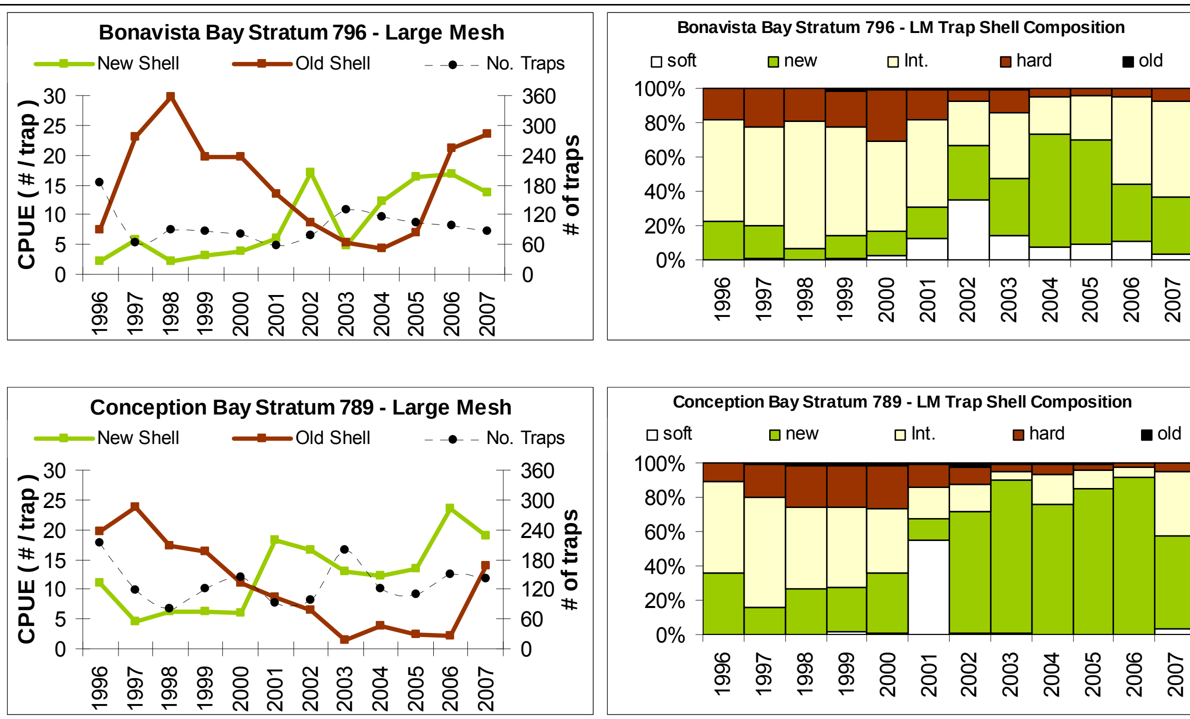


Figure 110b. Trends from large-mesh traps in shell condition of catches by stratum from inshore Division 3L trap surveys in Bonavista Bay (top panels) and Conception Bay (bottom panels), 1994-2007.

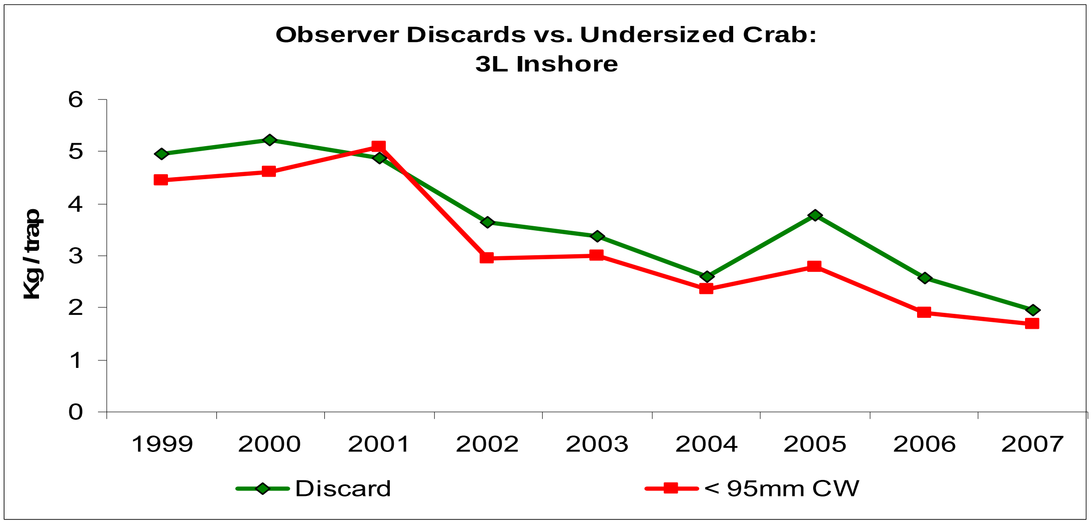


Figure 111. Trends in Division 3L inshore observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

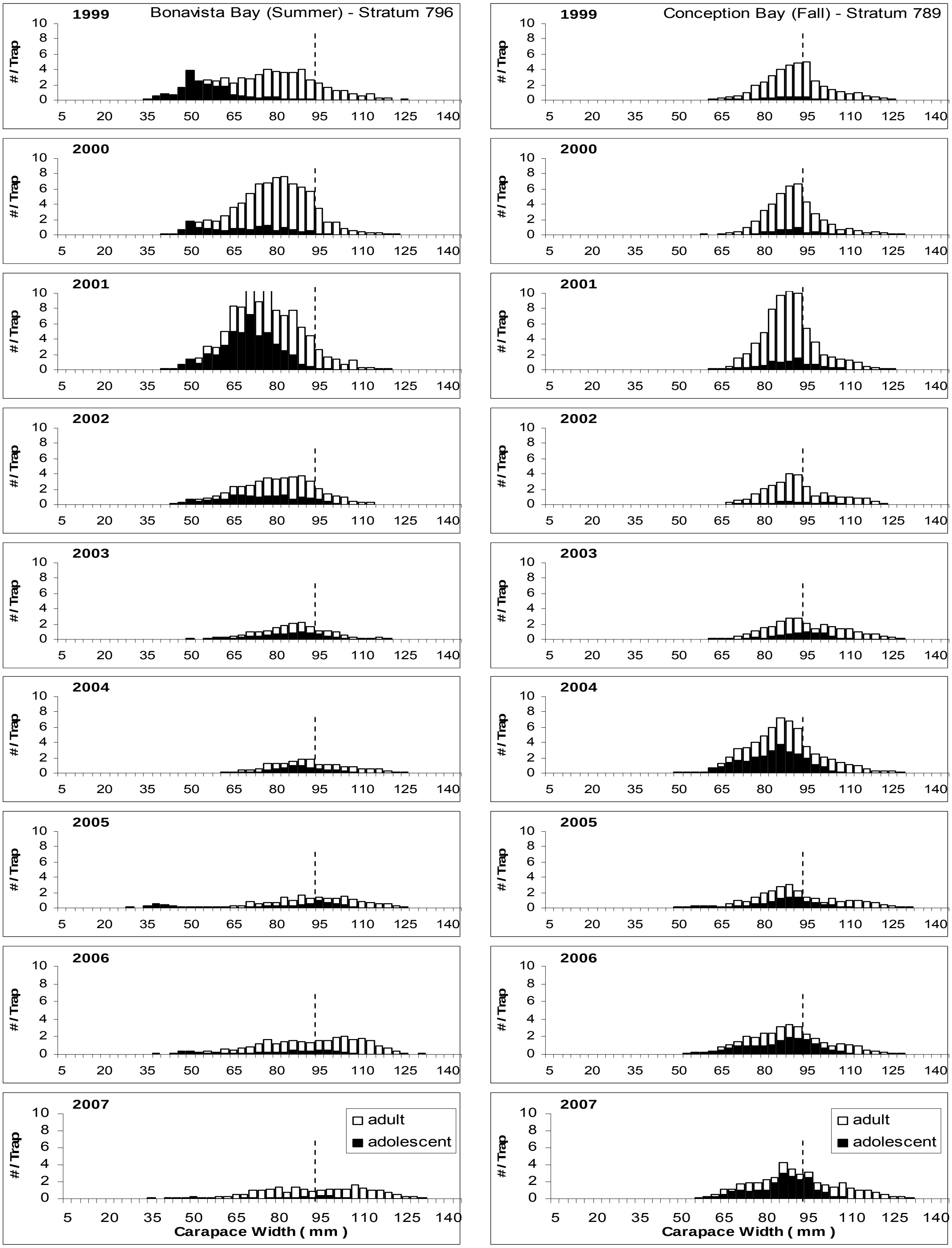


Figure 112. Inshore 3L trap surveys; small-claw (adolescent) vs. large-claw (adult) male crab size compositions by year from small-mesh traps within Bonavista Bay (left panels) and Conception Bay (right panels).

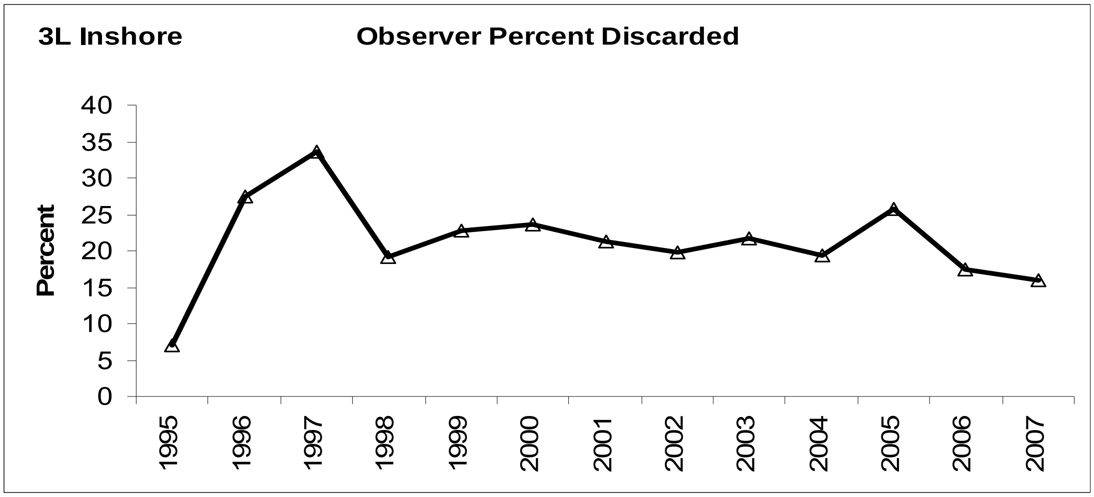


Figure 113. Trends in Division 3L inshore percentage of the catch discarded in the fishery.

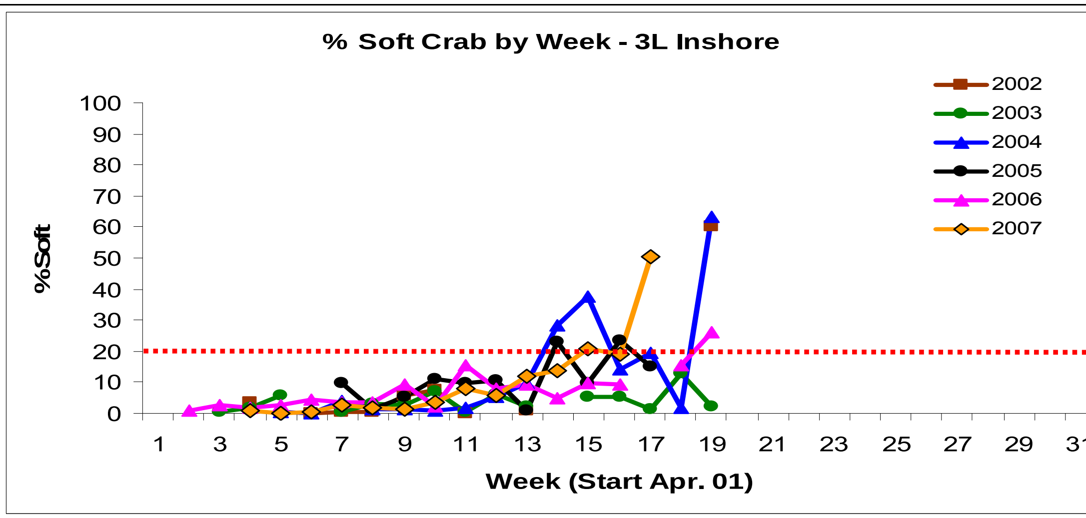


Figure 114. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Division 3L inshore fishery that are soft-shelled, by year (2002-2007), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed.)

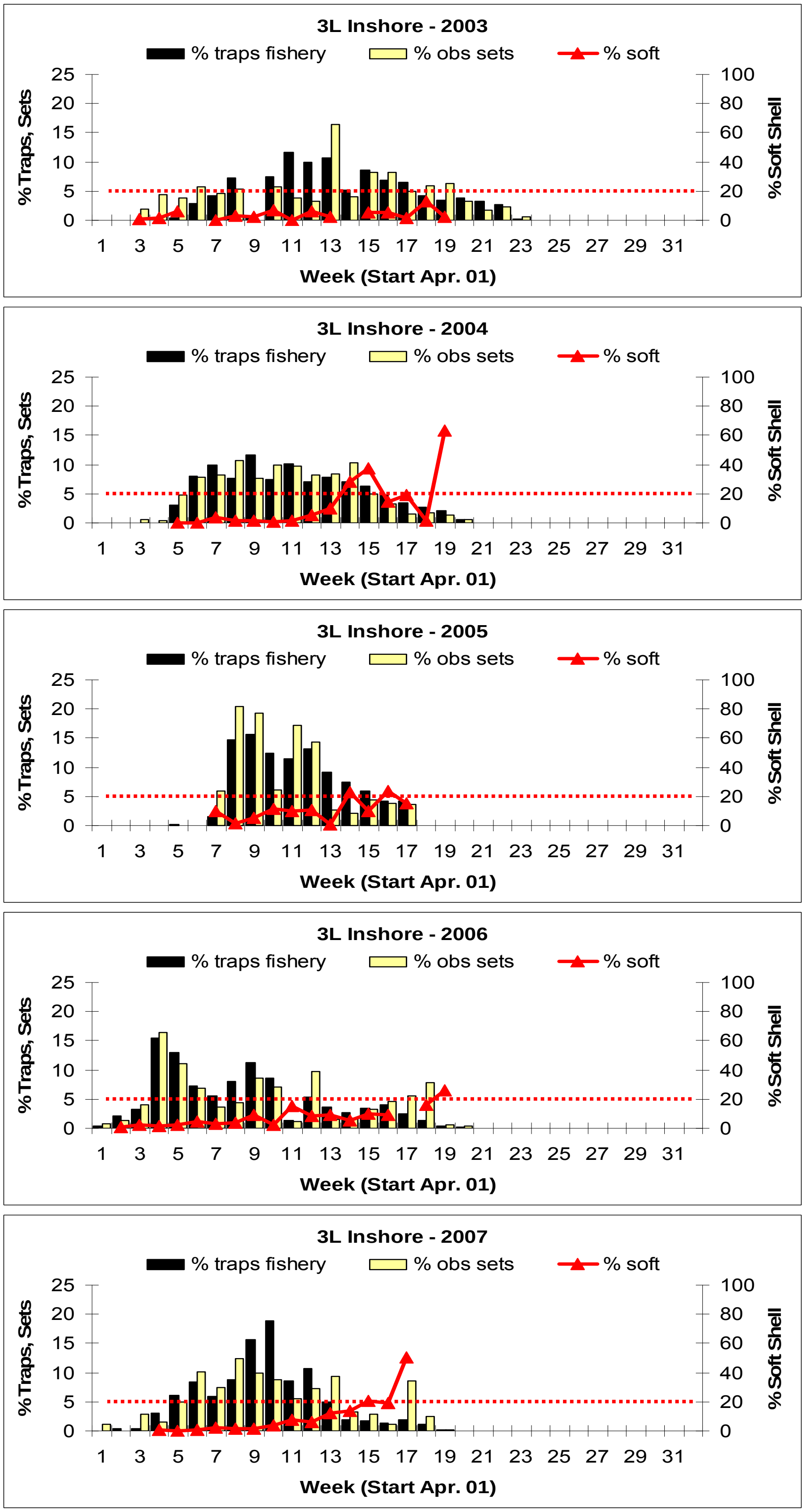


Figure 115. Seasonal trends in Division 3L inshore distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2003-2007. (Sample sizes of <10 observed sets/week removed.)

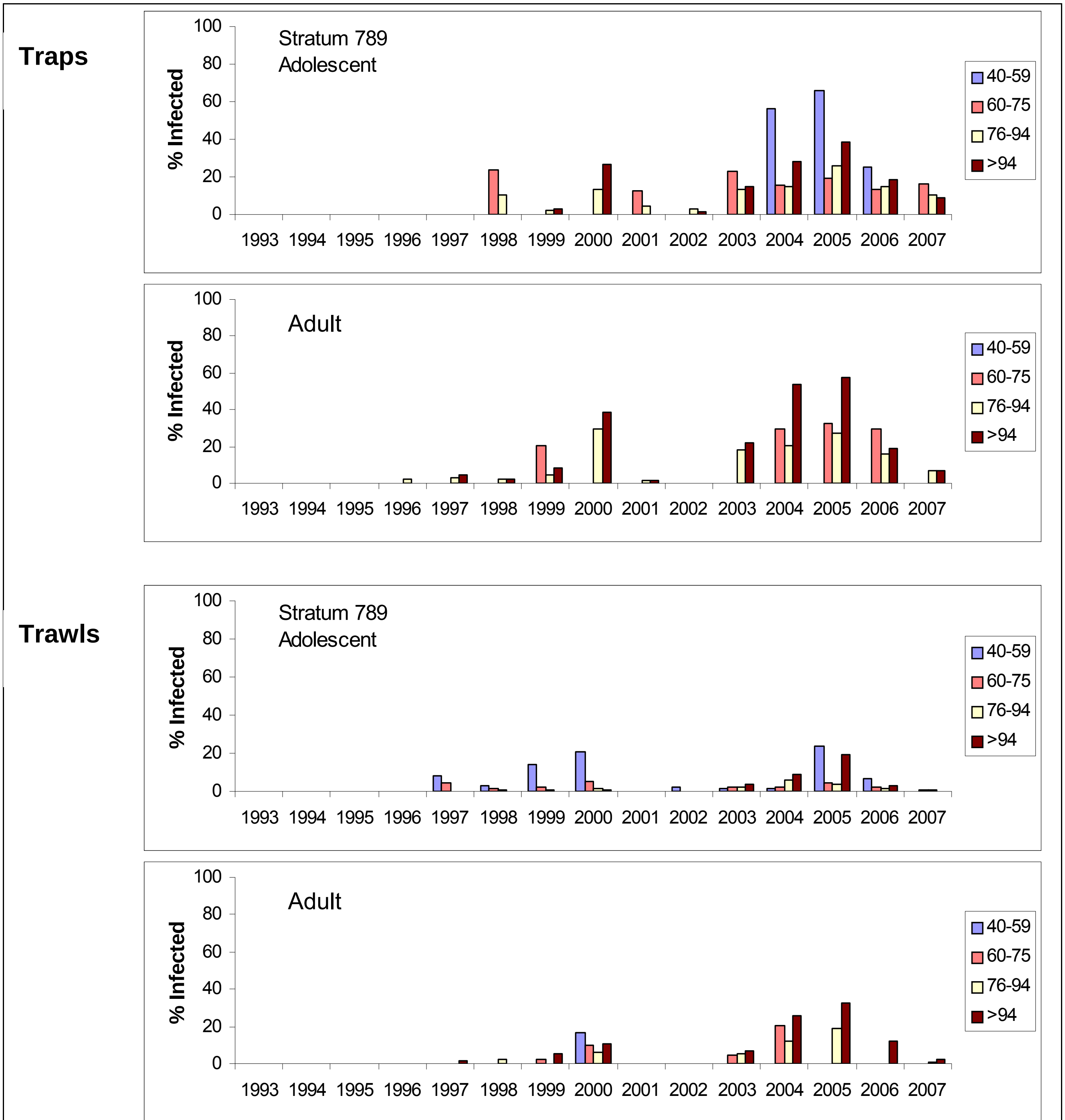


Figure 116. Incidence of BCD by stratum, year, and size group from trap (top panels) and trawl (bottom panels) surveys in Conception Bay; New-shelled males in adolescents (top) and adults (below).

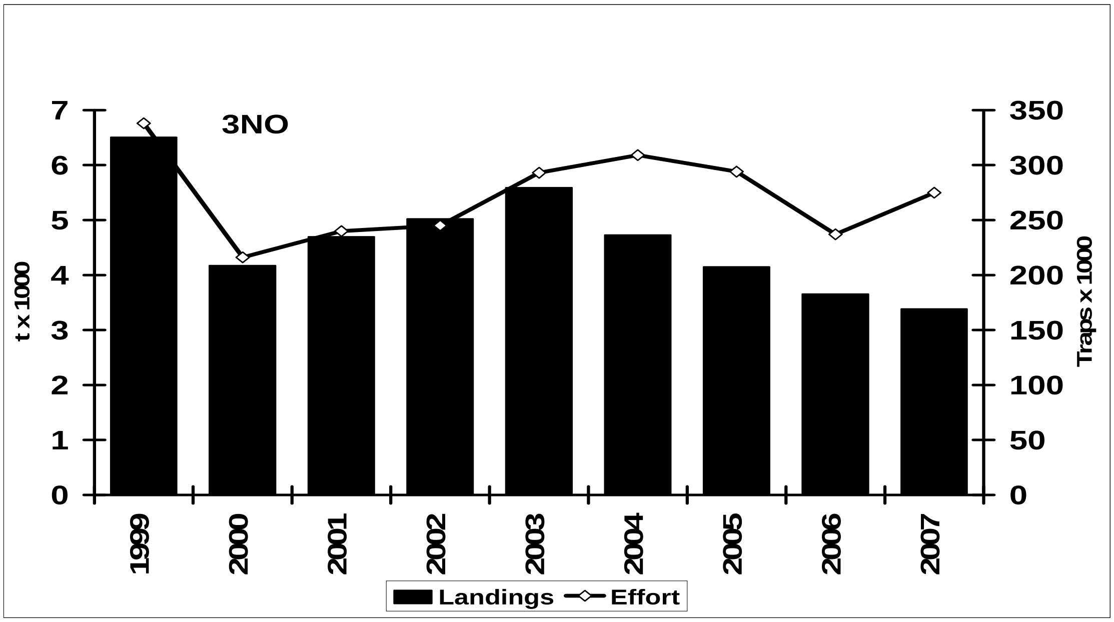


Figure 117. Trends in Division 3NO landings and fishing effort.

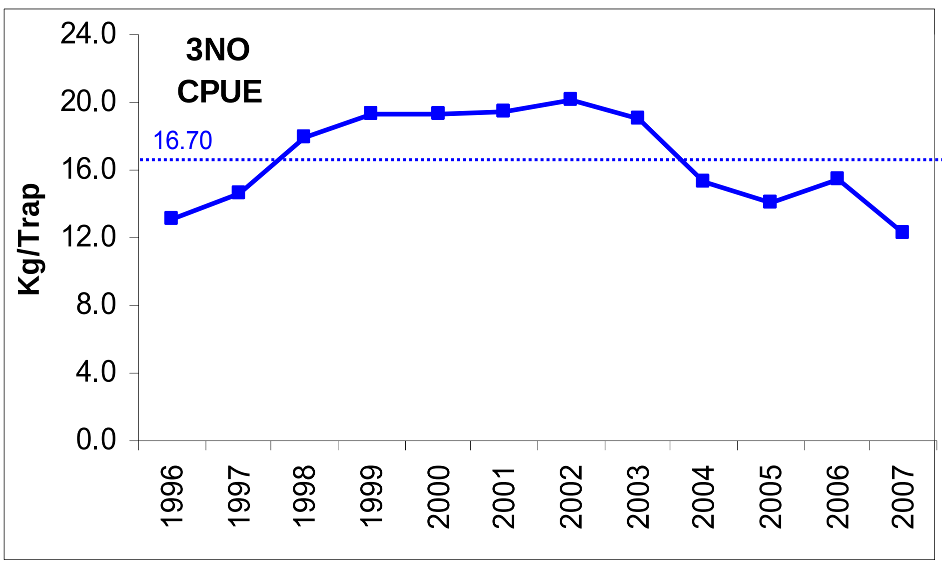


Figure 118. Trends in Division 3NO commercial CPUE in relation to the long-term average (dotted line).

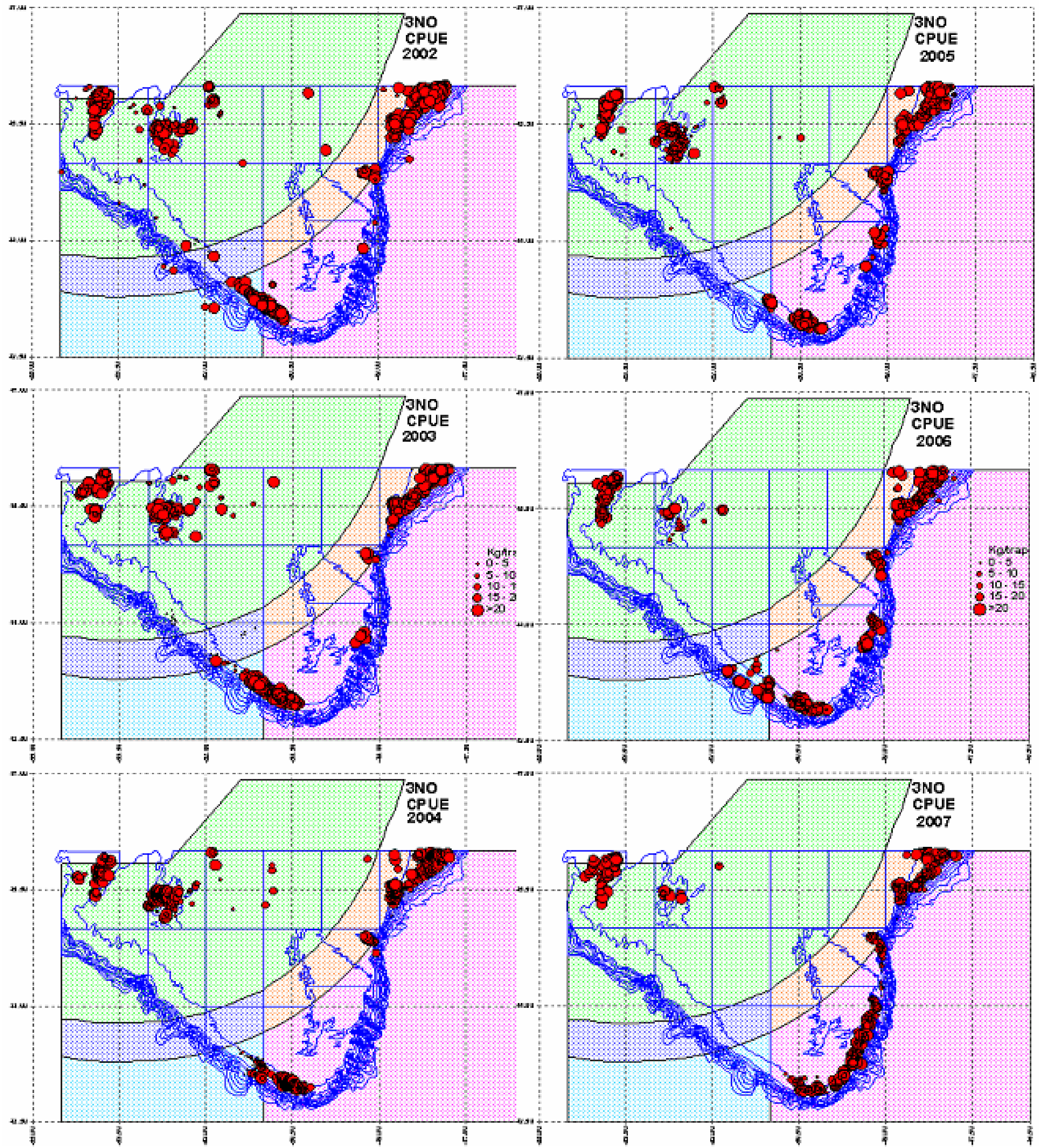


Figure 119. Spatial distribution of Division 3NO commercial CPUE by year.

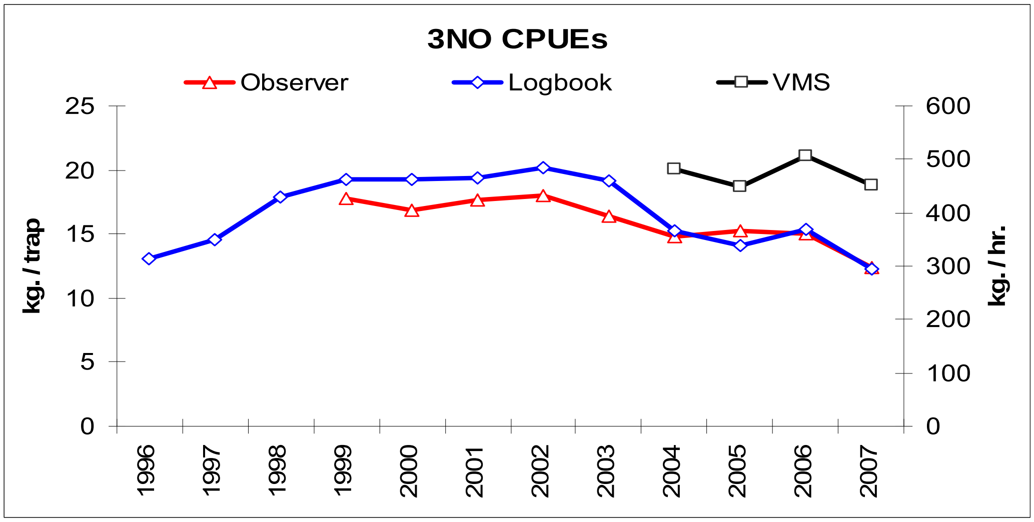


Figure 120. Trends in commercial logbook-based CPUE, observer-based CPUE and VMS-based CPUE in the Division 3NO fishery.

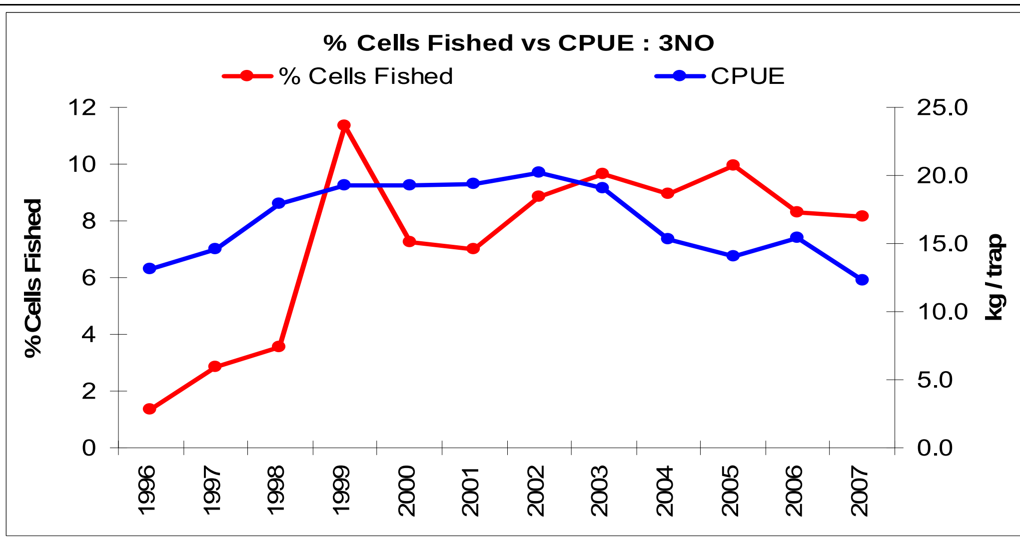


Figure 121. Trends in Division 3NO commercial CPUE vs. the percentage of 5' x 5' cells fished.

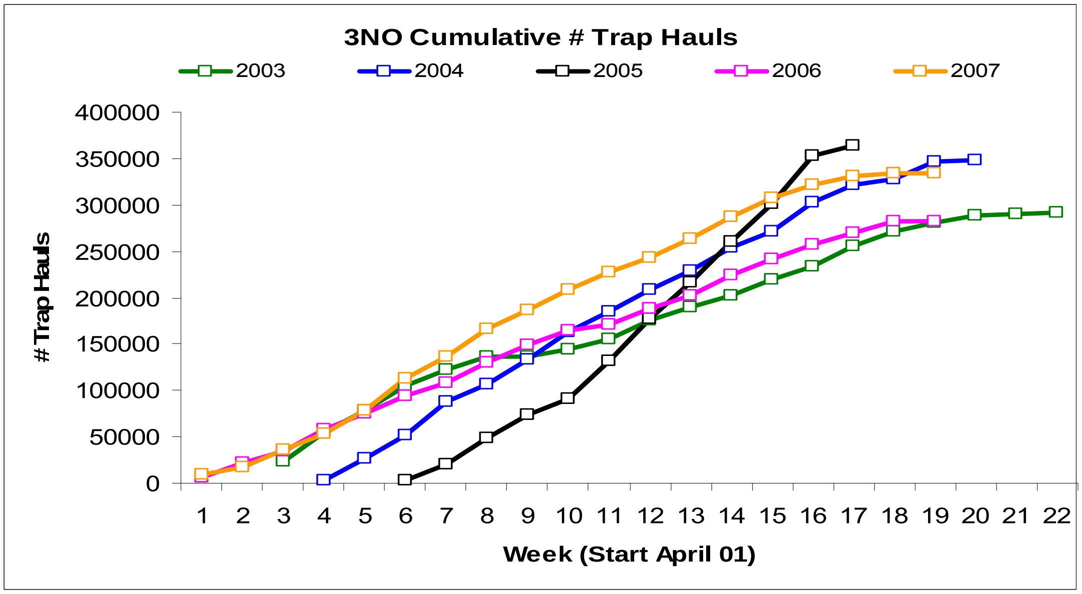
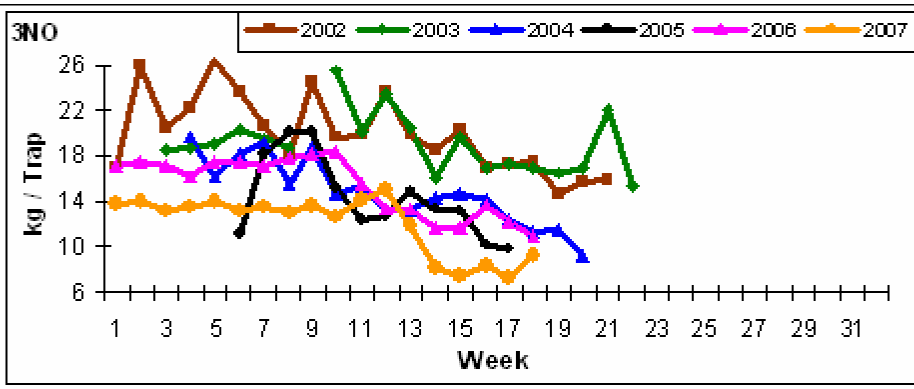


Figure 122. Seasonal trends in fishing effort for Division 3NO during 2003-07.

a)



b)

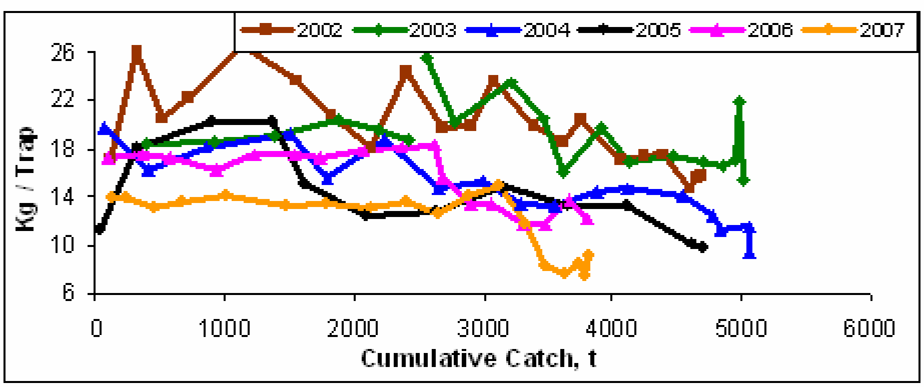


Figure 123. Seasonal trends in logbook-based CPUE for Division 3NO during 2002-07; (a) by week, and (b) in relation to cumulative catch.

a)

b)

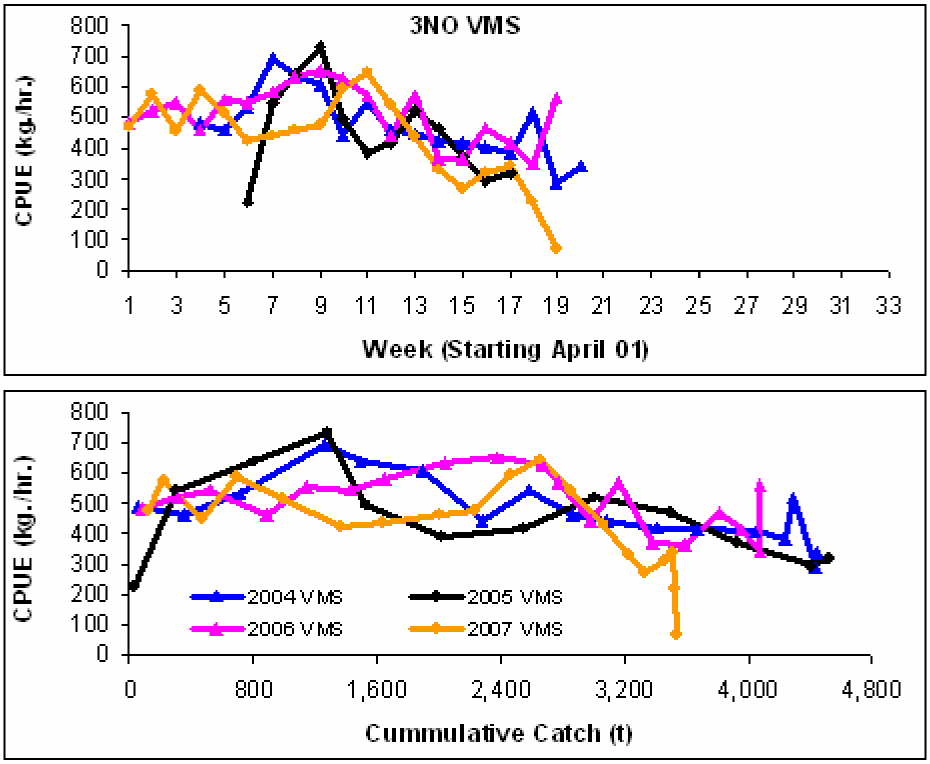


Figure 124. Seasonal trends in VMS-based CPUE for Division 3NO during 2002-07; (a) by week, and (b) in relation to cumulative catch.

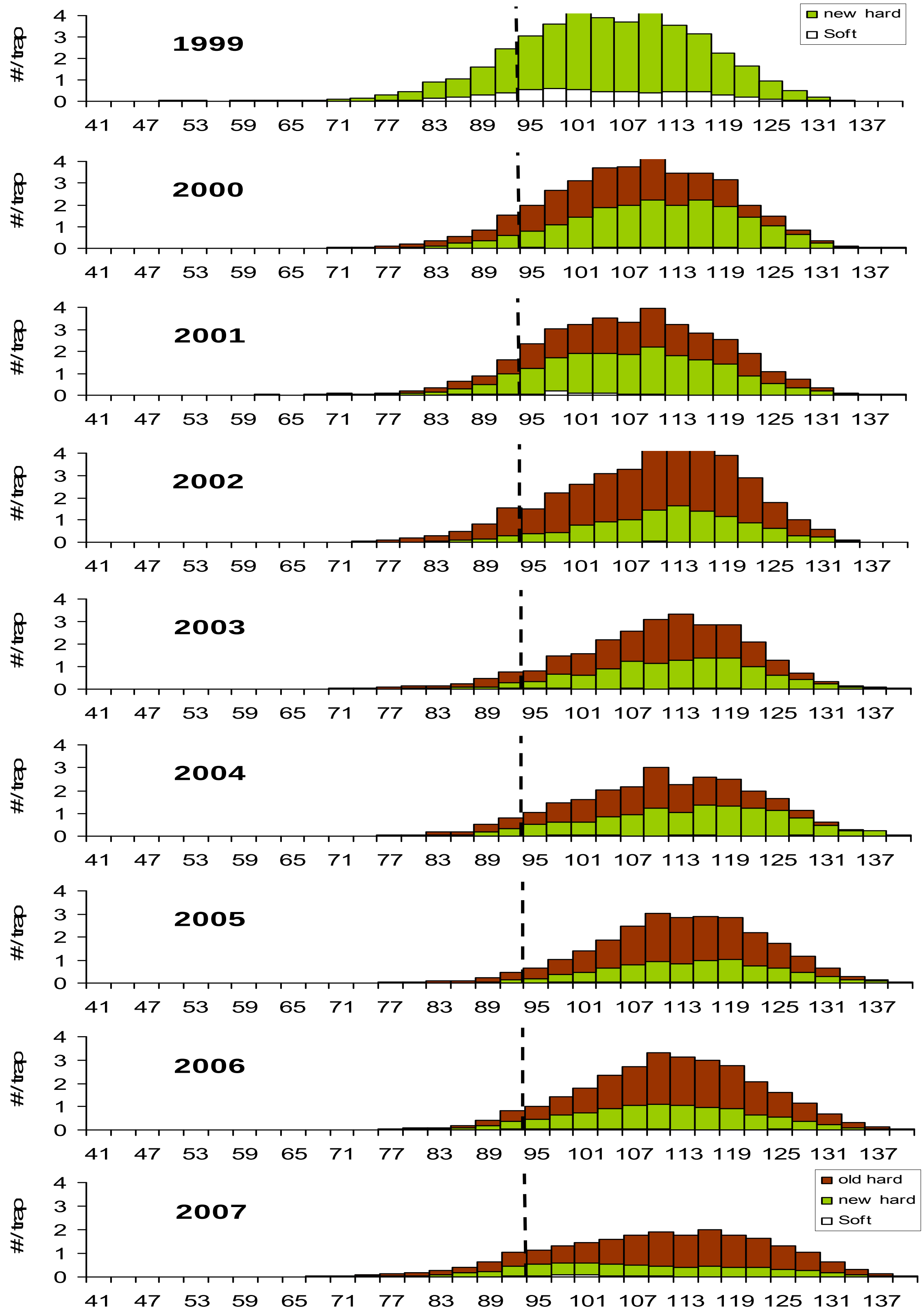


Figure 125. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Division 3NO. The vertical dashed line indicates the minimum legal size.

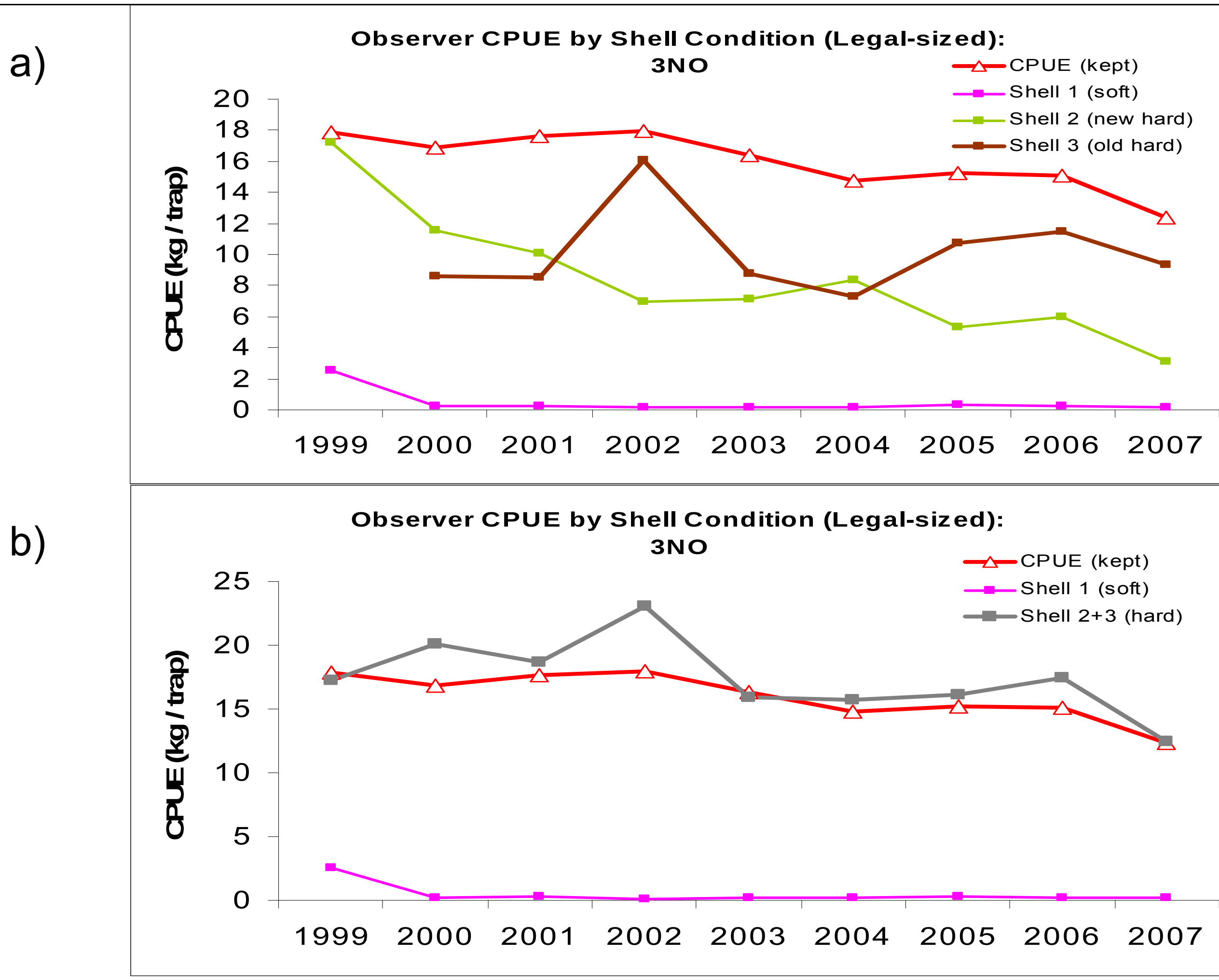


Figure 126. Trends in Division 3NO observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

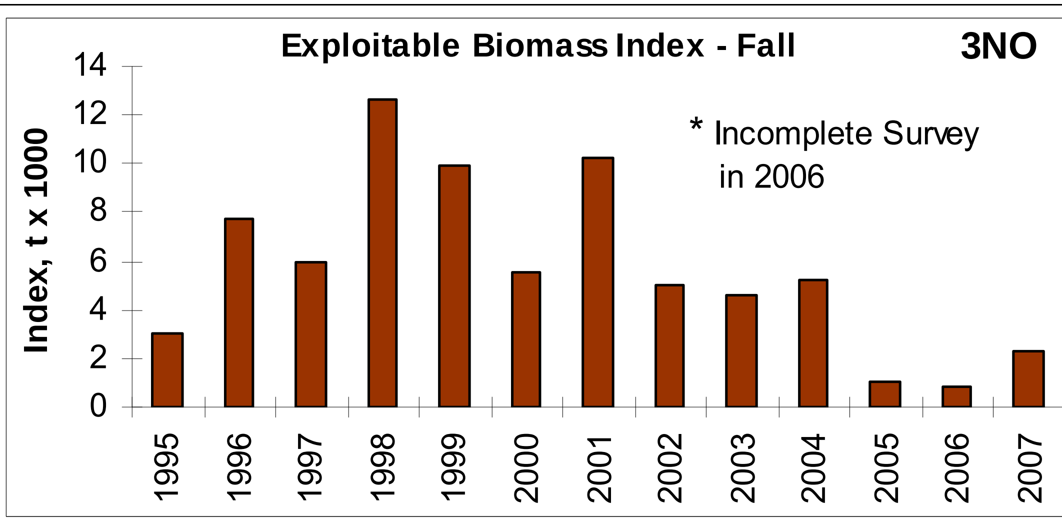
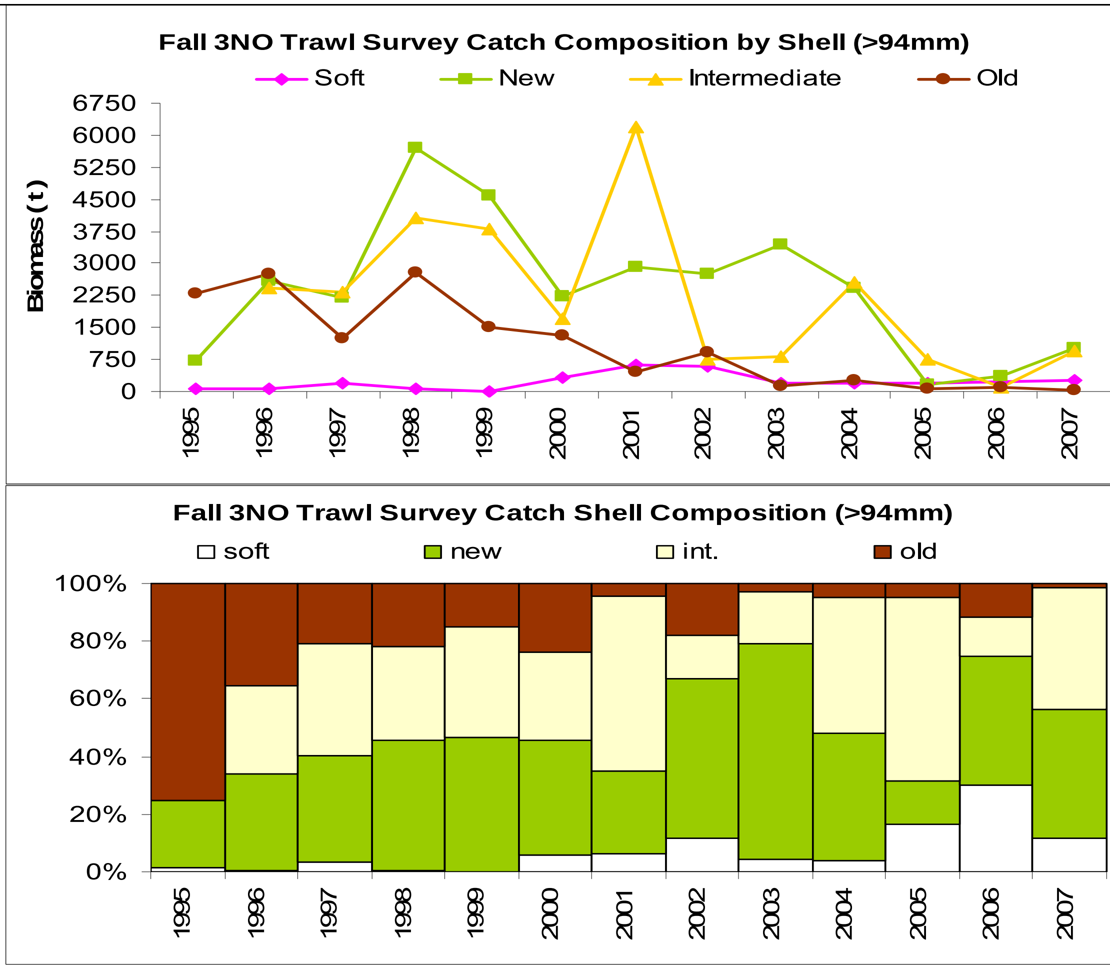


Figure 127. Trends in the Division 3NO fall trawl survey exploitable biomass index.

a)



b)

Figure 128. Trends, by shell condition, in exploitable males for Division 3NO from fall trawl surveys for; a) biomass, and (b) percentages of the total catch.

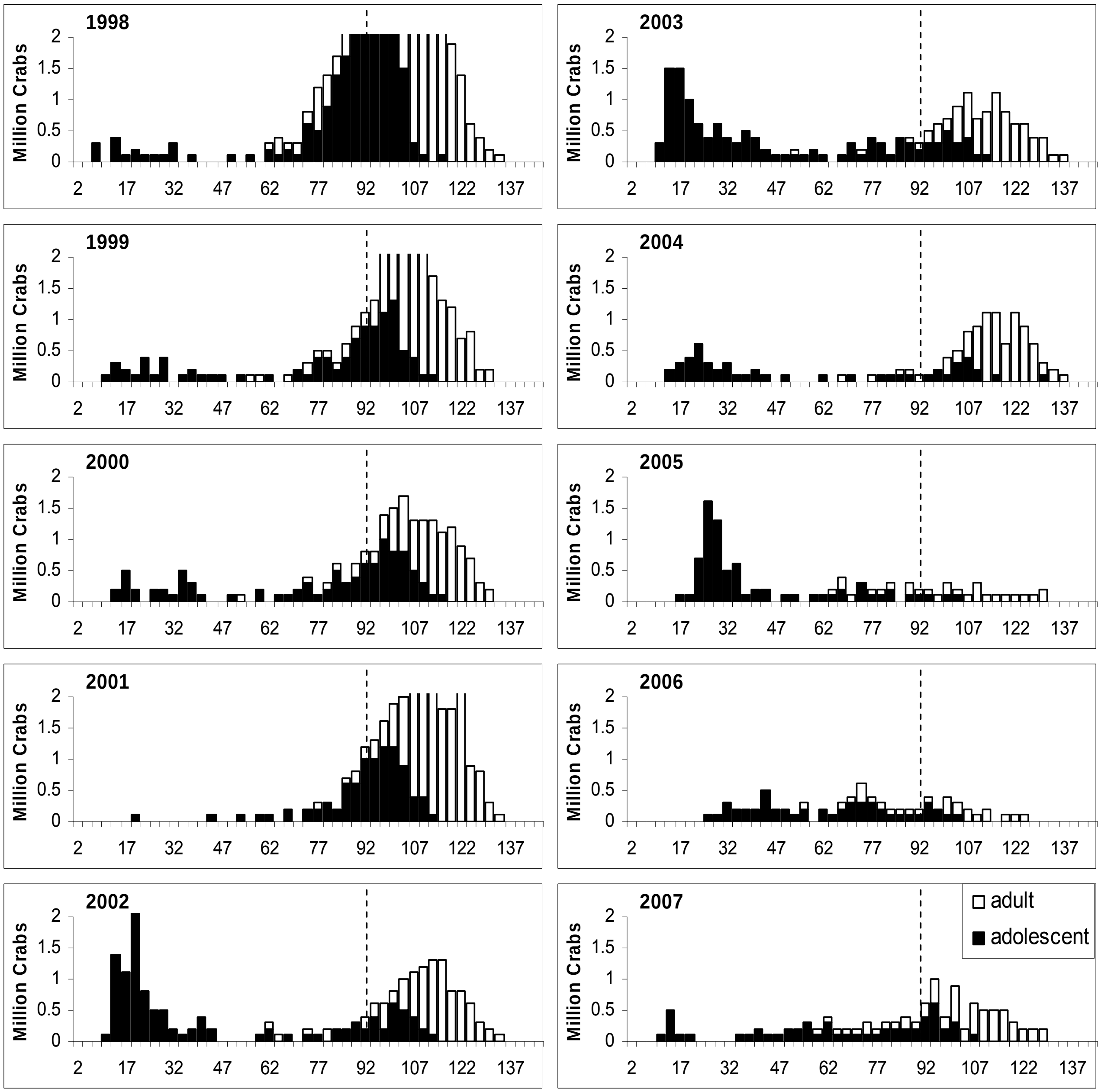


Figure 129. Distribution of abundance (index) by carapace width for Division 3NO juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line.

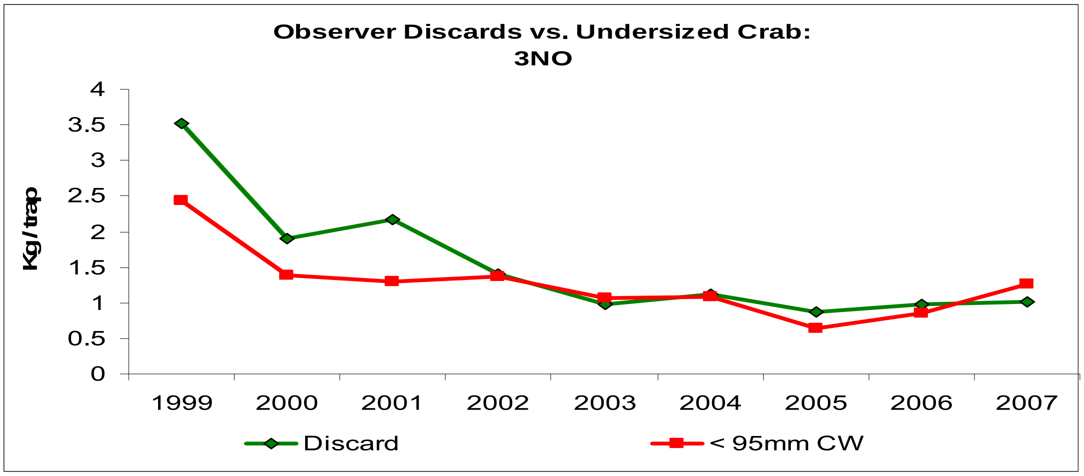


Figure 130. Trends in Division 3NO observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

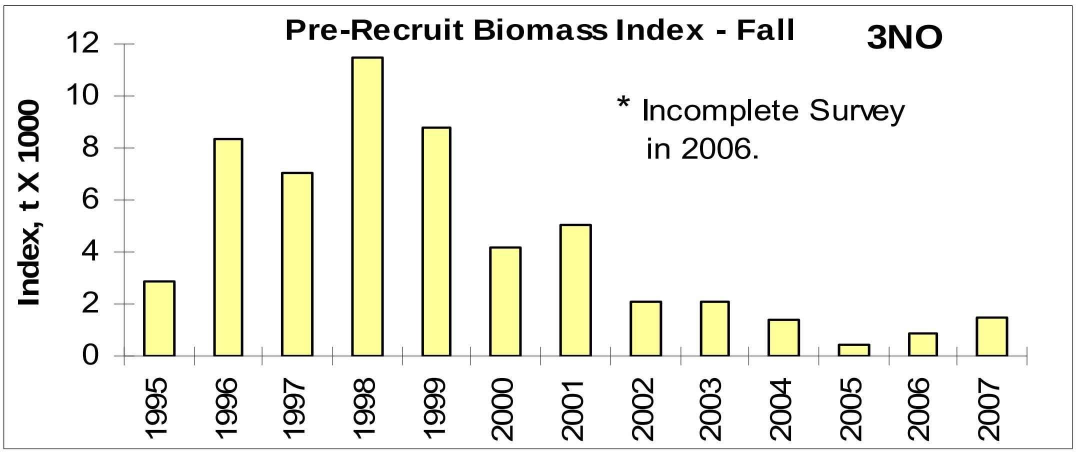


Figure 131. Trends in the Division 3NO fall trawl survey pre-recruit biomass index.

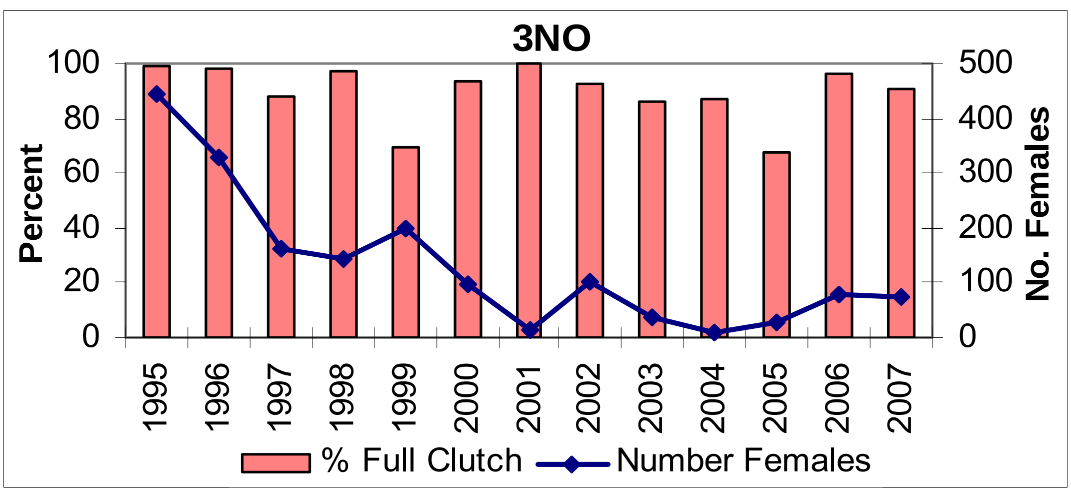


Figure 132. Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Division 3NO from fall multi-species surveys.

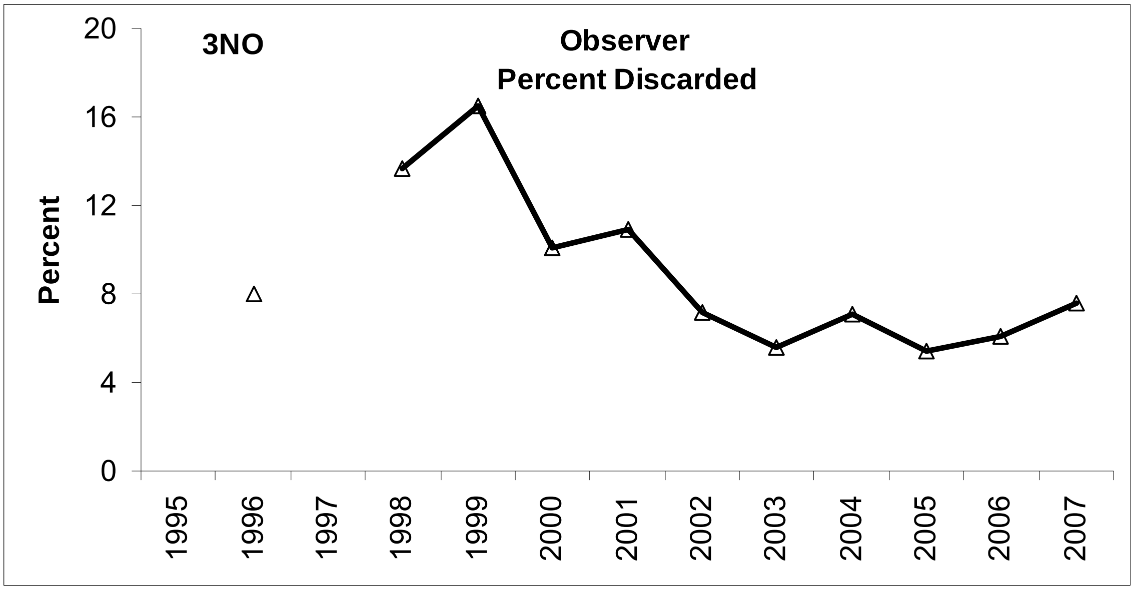


Figure 133. Trends in Division 3NO mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery.

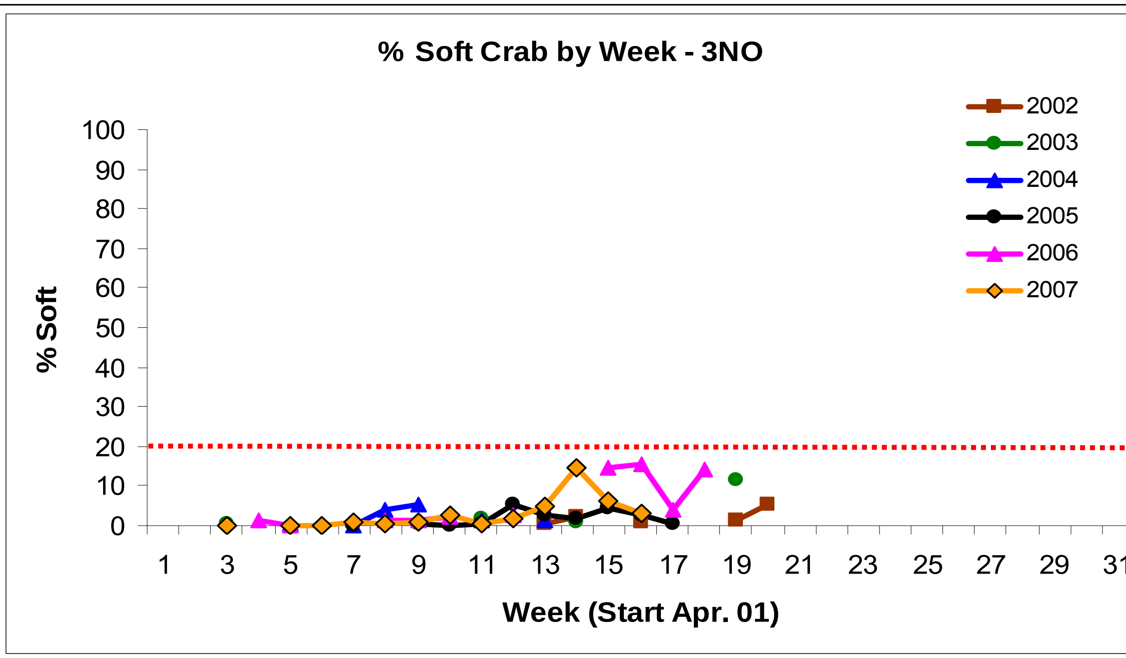


Figure 134. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Division 3NO fishery that are soft-shelled, by year (2002-07), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed.)

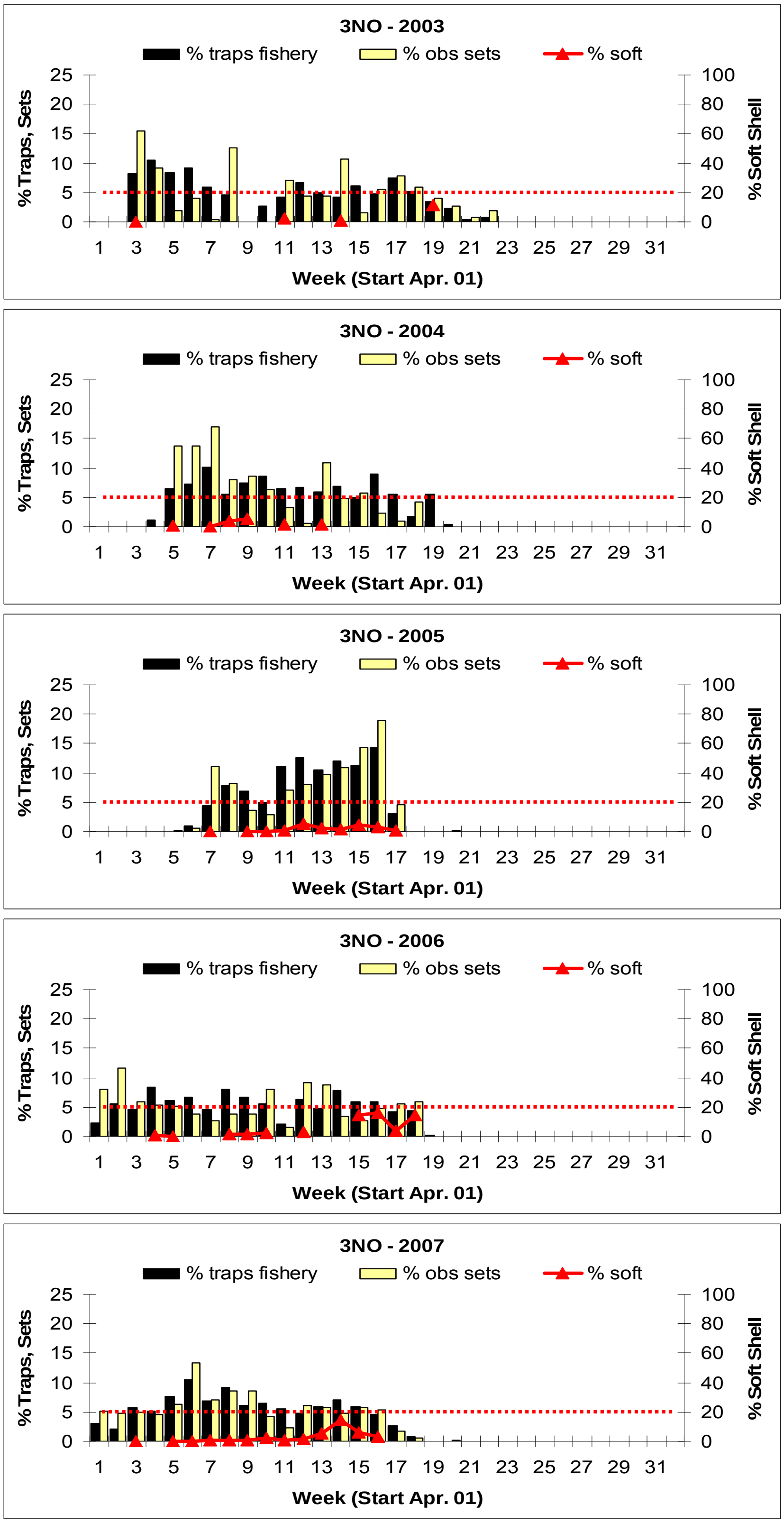
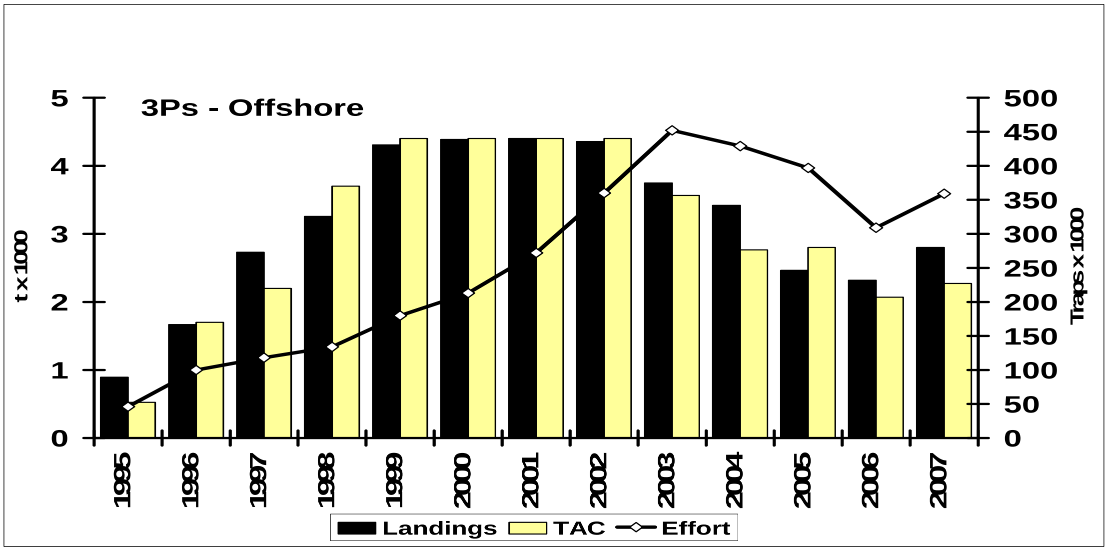


Figure 135. Seasonal trends in Division 3NO distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2003-2007. (Sample sizes of <10 observed sets/week removed)



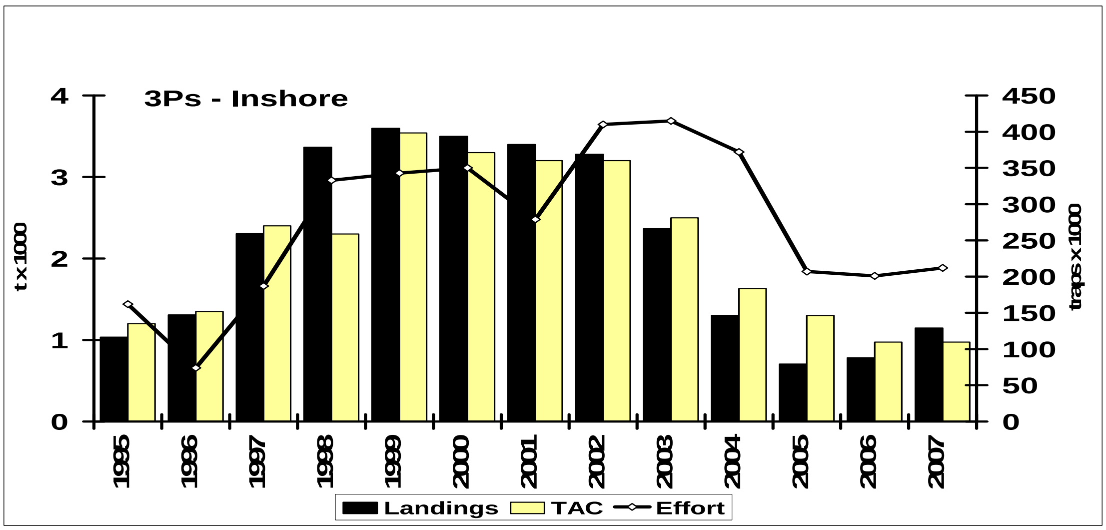


Figure 136. Trends in Subdivision 3Ps landings, TAC, and fishing effort for the offshore (above) and inshore (below).

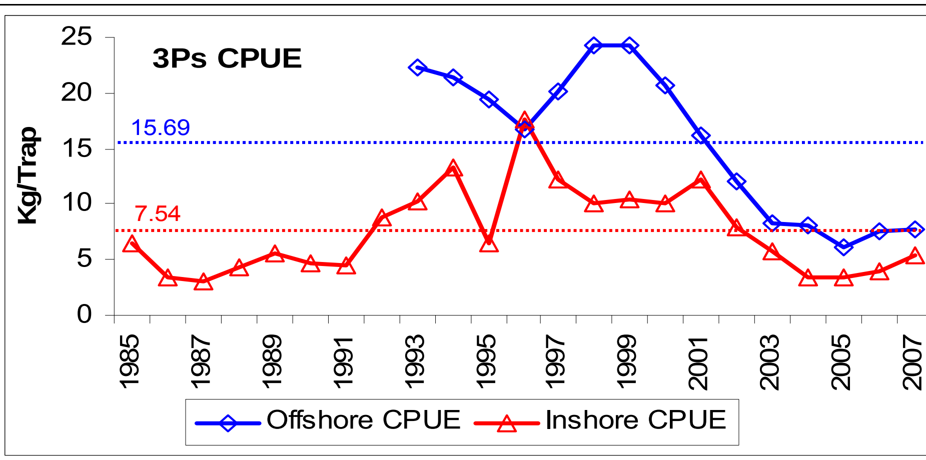


Figure 137. Trends in Subdivision 3Ps offshore and inshore commercial CPUE in relation to their long-term averages (dotted lines).

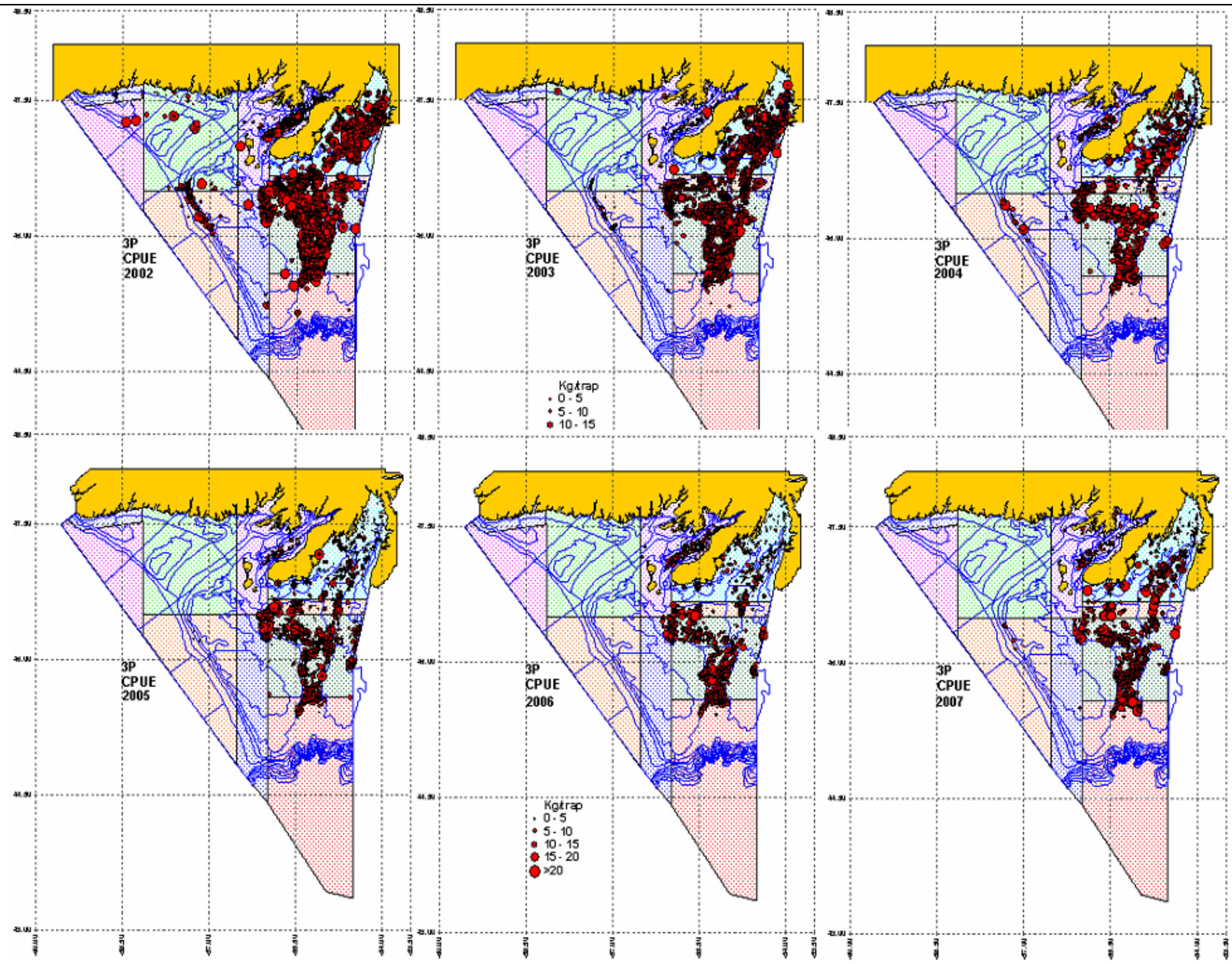


Figure 138. Spatial distribution of Subdivision 3Ps commercial CPUE by year.

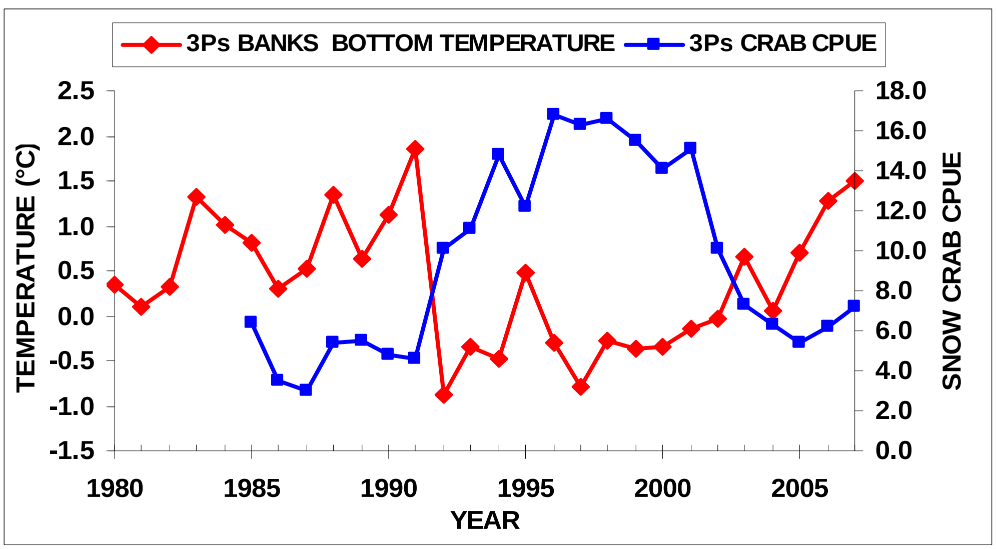


Figure 139. Trends in commercial CPUE in the Subdivision 3Ps fishery (offshore and inshore combined) vs. bottom temperature at a seven year lag.

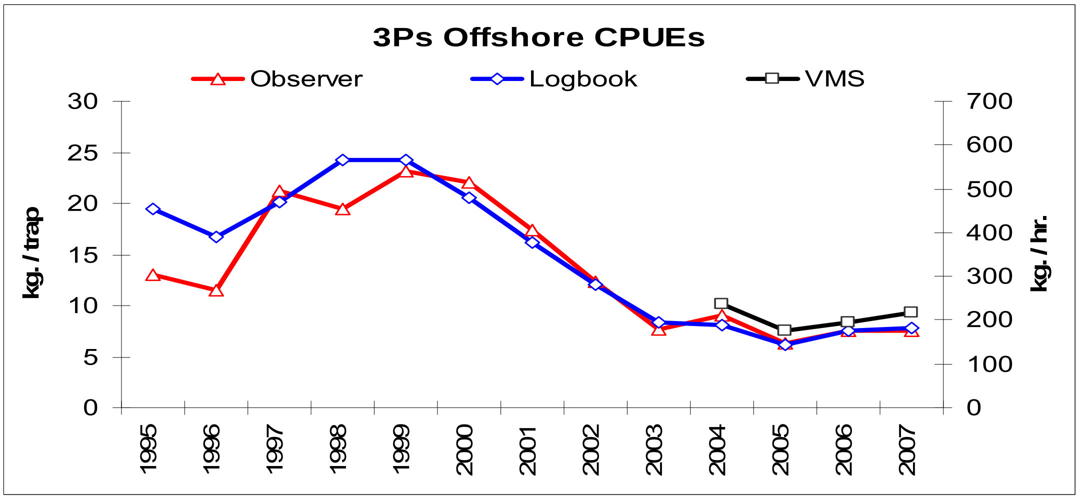


Figure 140. Trends in commercial logbook-based CPUE, observer-based CPUE and VMS-based CPUE in the Subdivision 3Ps offshore fishery.

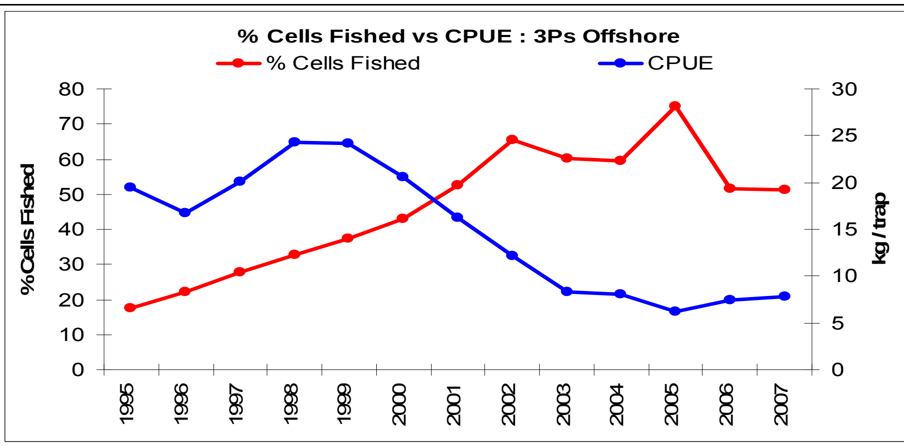


Figure 141. Trends in Division 3L offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

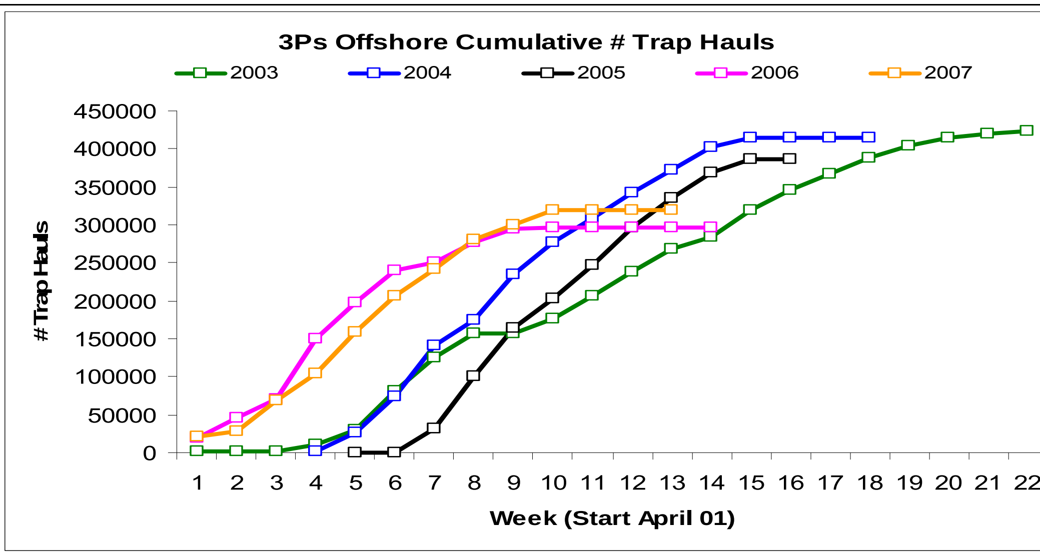


Figure 142. Seasonal trends in fishing effort for Subdivision 3Ps offshore during 2003-07.

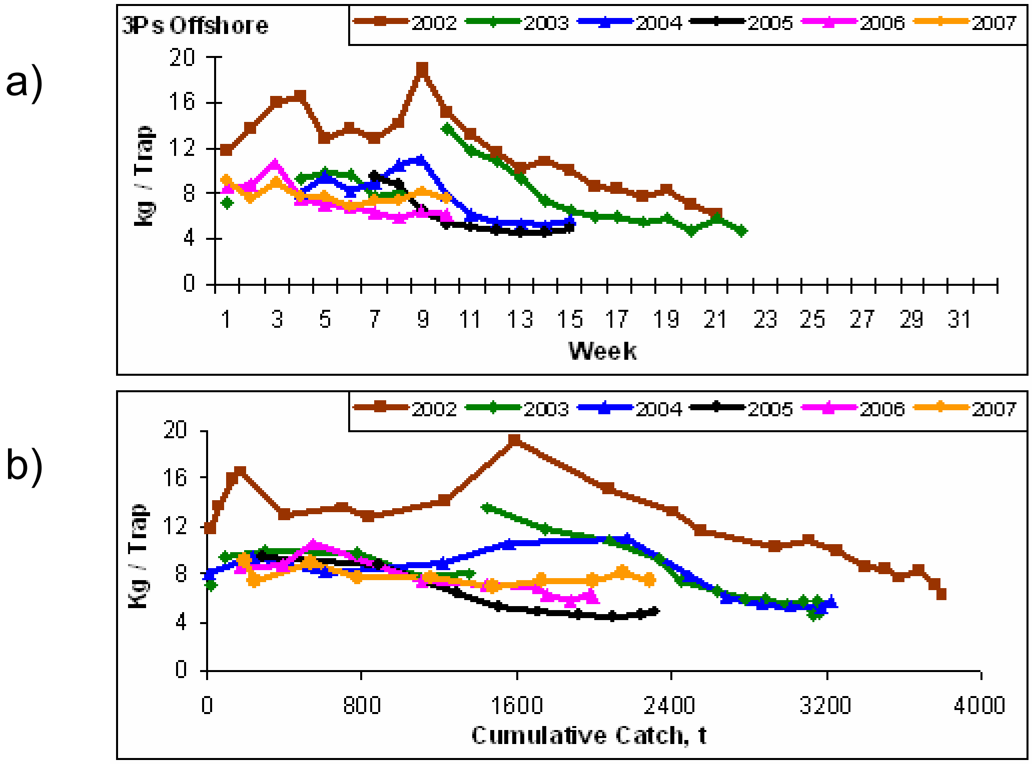


Figure 143. Seasonal trends in logbook-based CPUE for Subdivision 3Ps offshore during 2002-07; (a) by week, and (b) in relation to cumulative catch.

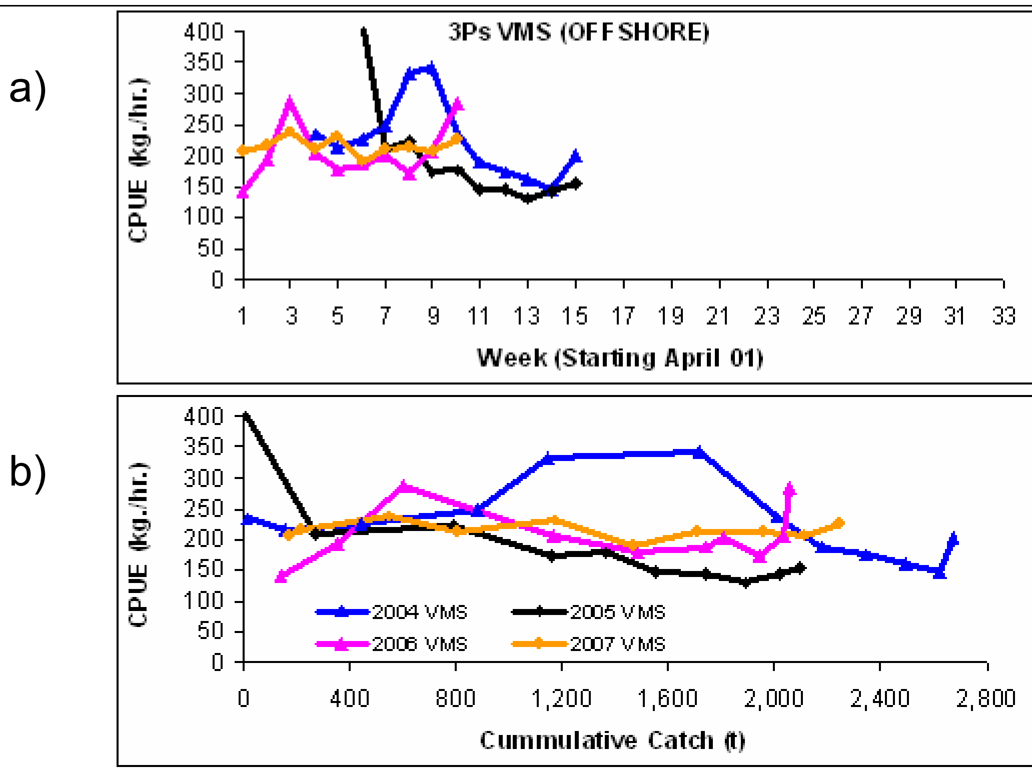


Figure 144. Seasonal trends in VMS-based CPUE for Subdivision 3Ps offshore during 2002-07; (a) by week, and (b) in relation to cumulative catch.

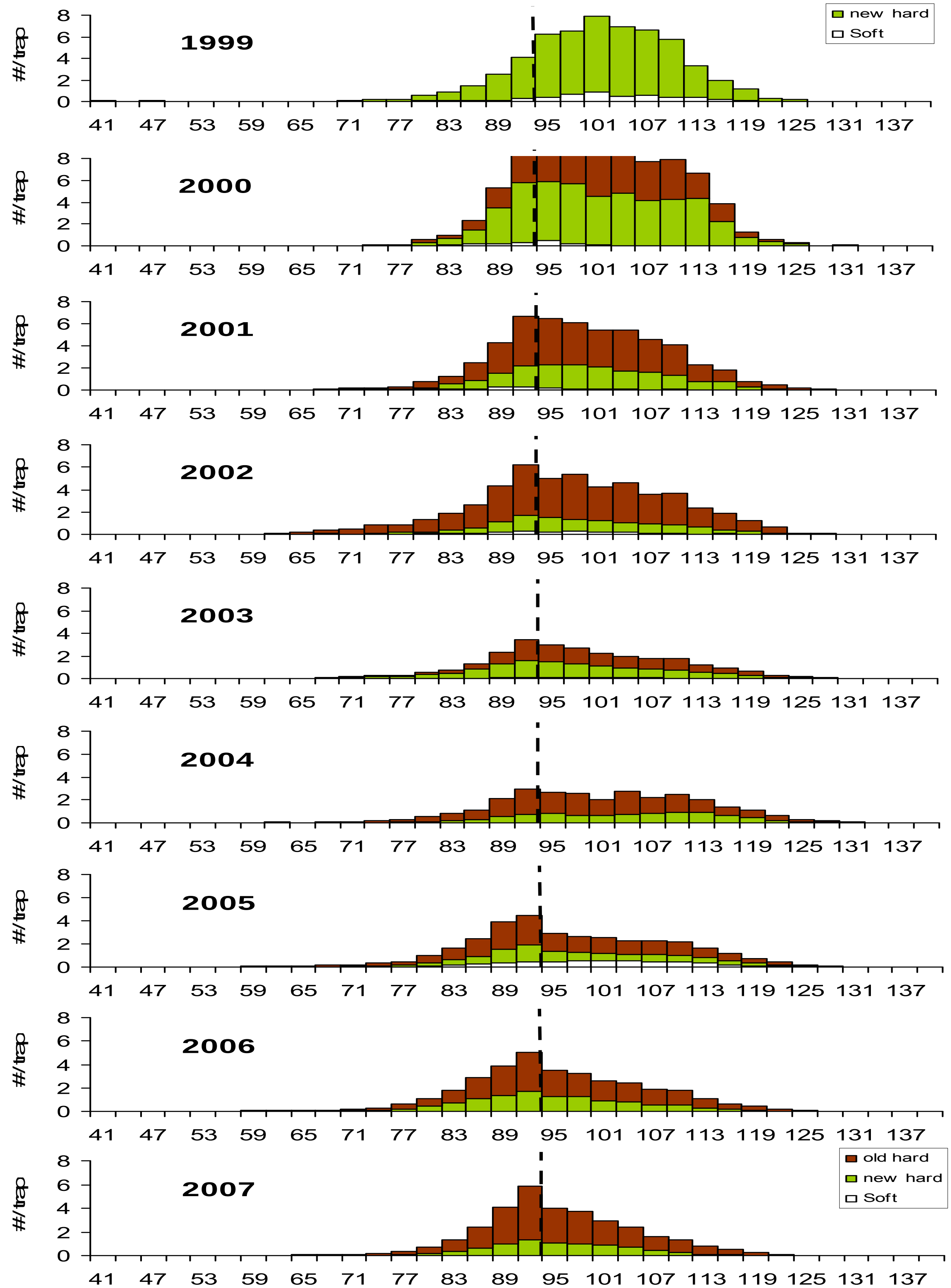


Figure 145. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Subdivision 3Ps offshore. The vertical dashed line indicates the minimum legal size.

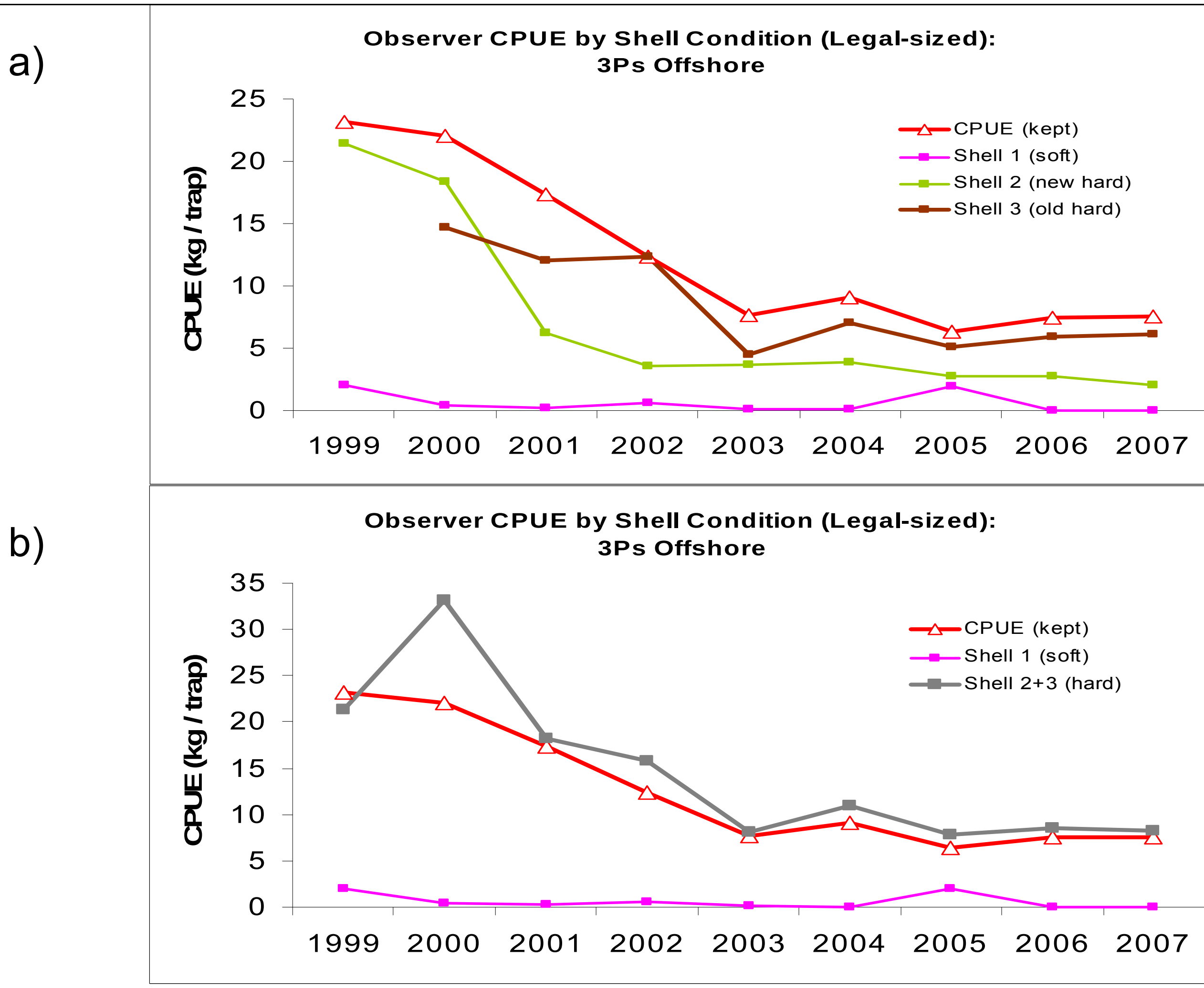


Figure 146. Trends in Subdivision 3Ps offshore observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

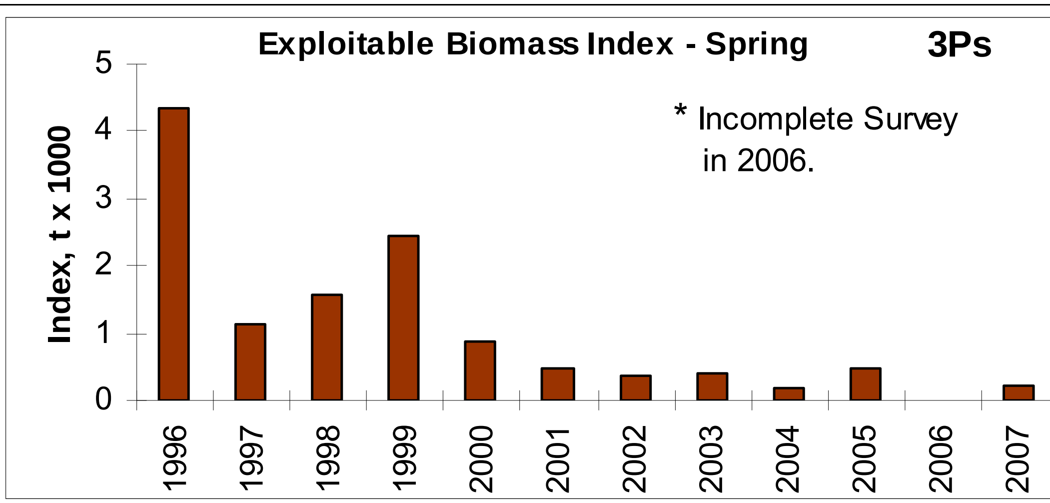


Figure 147. Trends in the Subdivision 3Ps spring trawl survey exploitable biomass index.

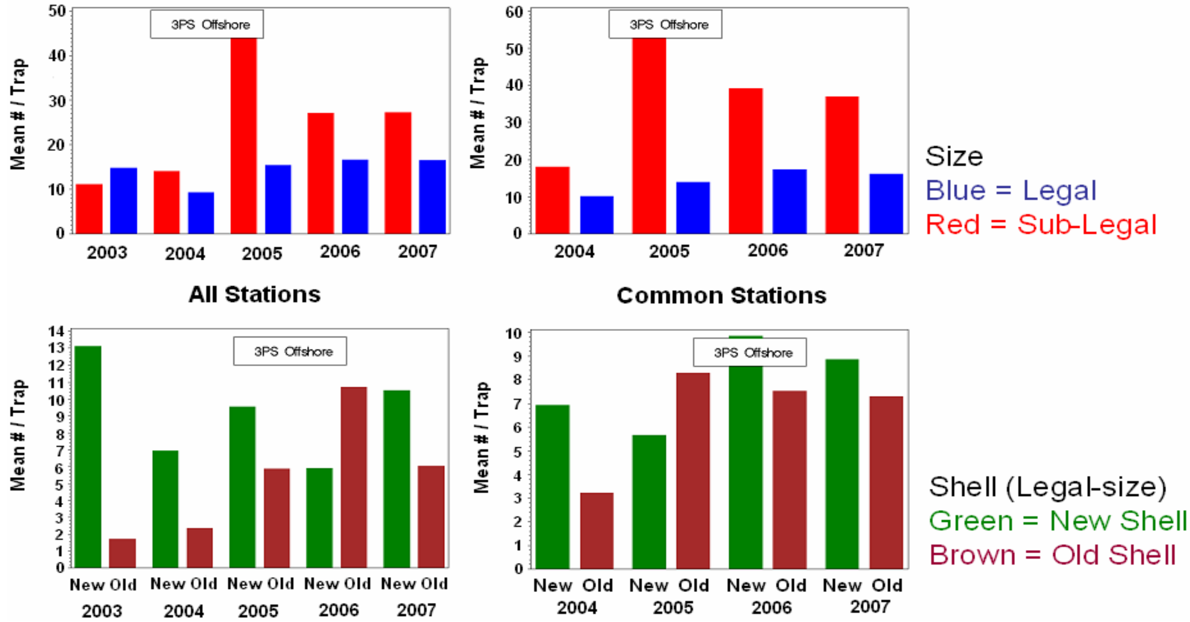


Figure 148. Trends in CPUE for size composition (above) and shell condition (below) from industry-DFO collaborative post-season trap surveys for Subdivision 3Ps offshore from all stations (left) and common stations (right).

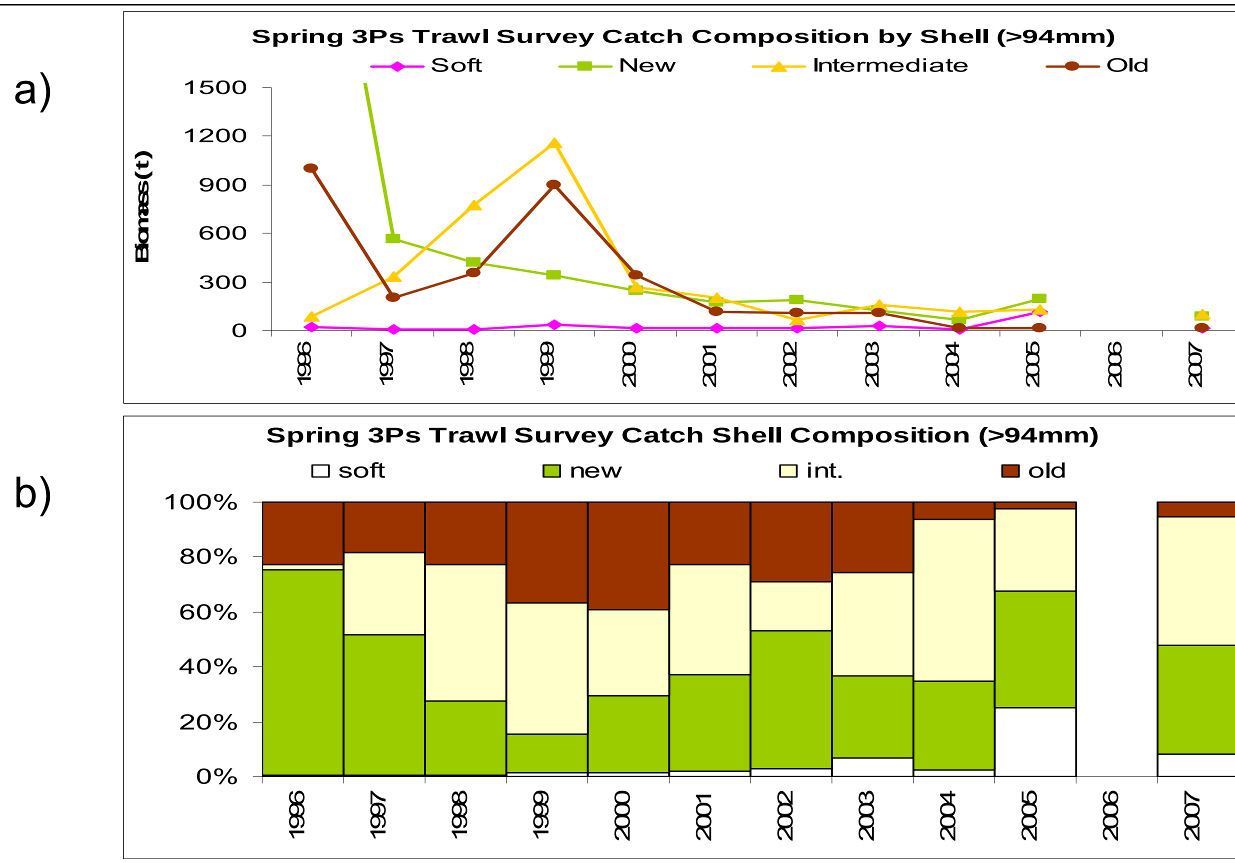


Figure 149. Trends, by shell condition, in exploitable males for Subdivision 3Ps offshore from fall trawl surveys for; a) biomass, and (b) percentages of the total catch.

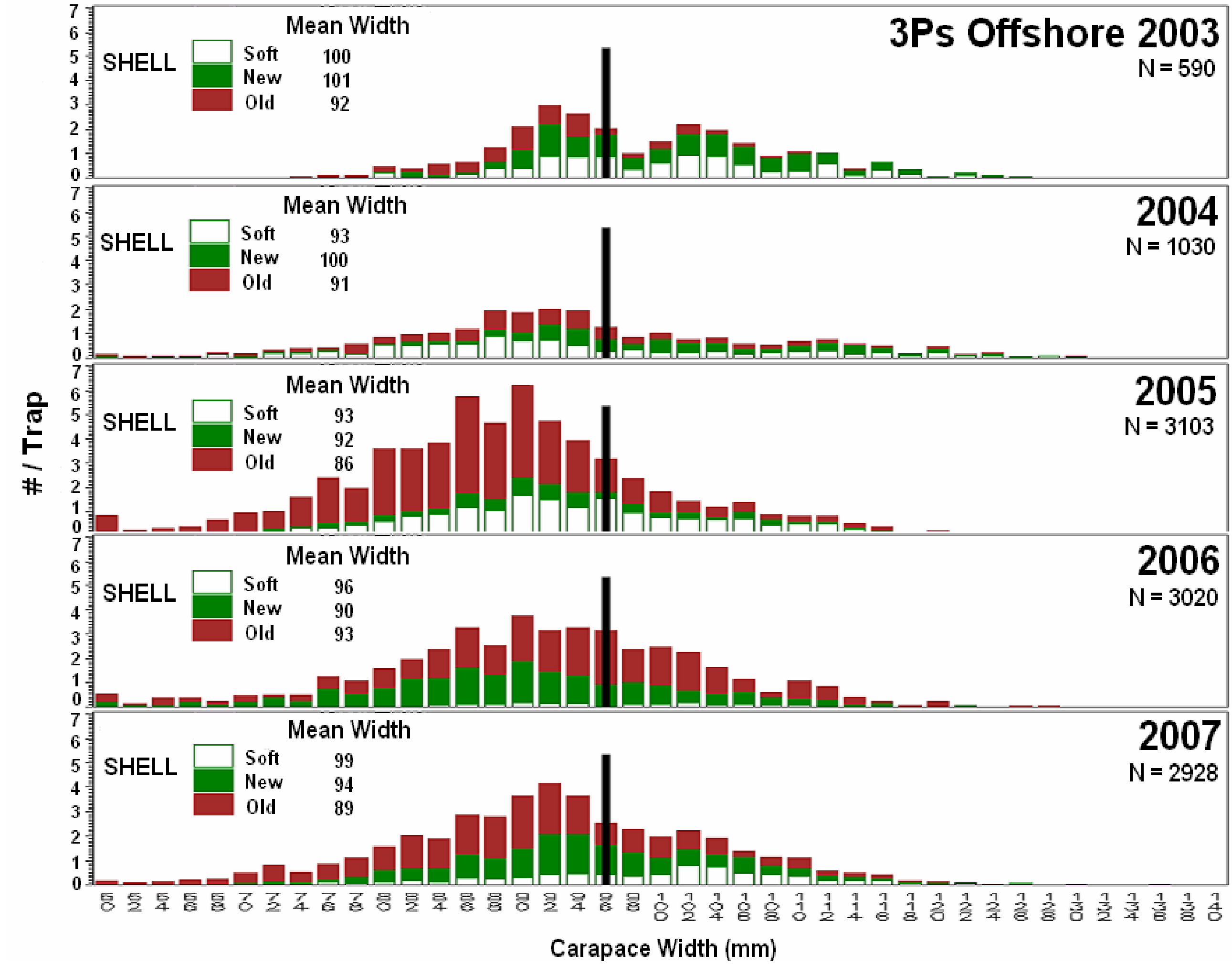


Figure 150. Trends in male carapace width distributions from industry-DFO post-season trap surveys for Subdivision 3Ps offshore (all stations). The vertical solid line indicates the minimum legal size.

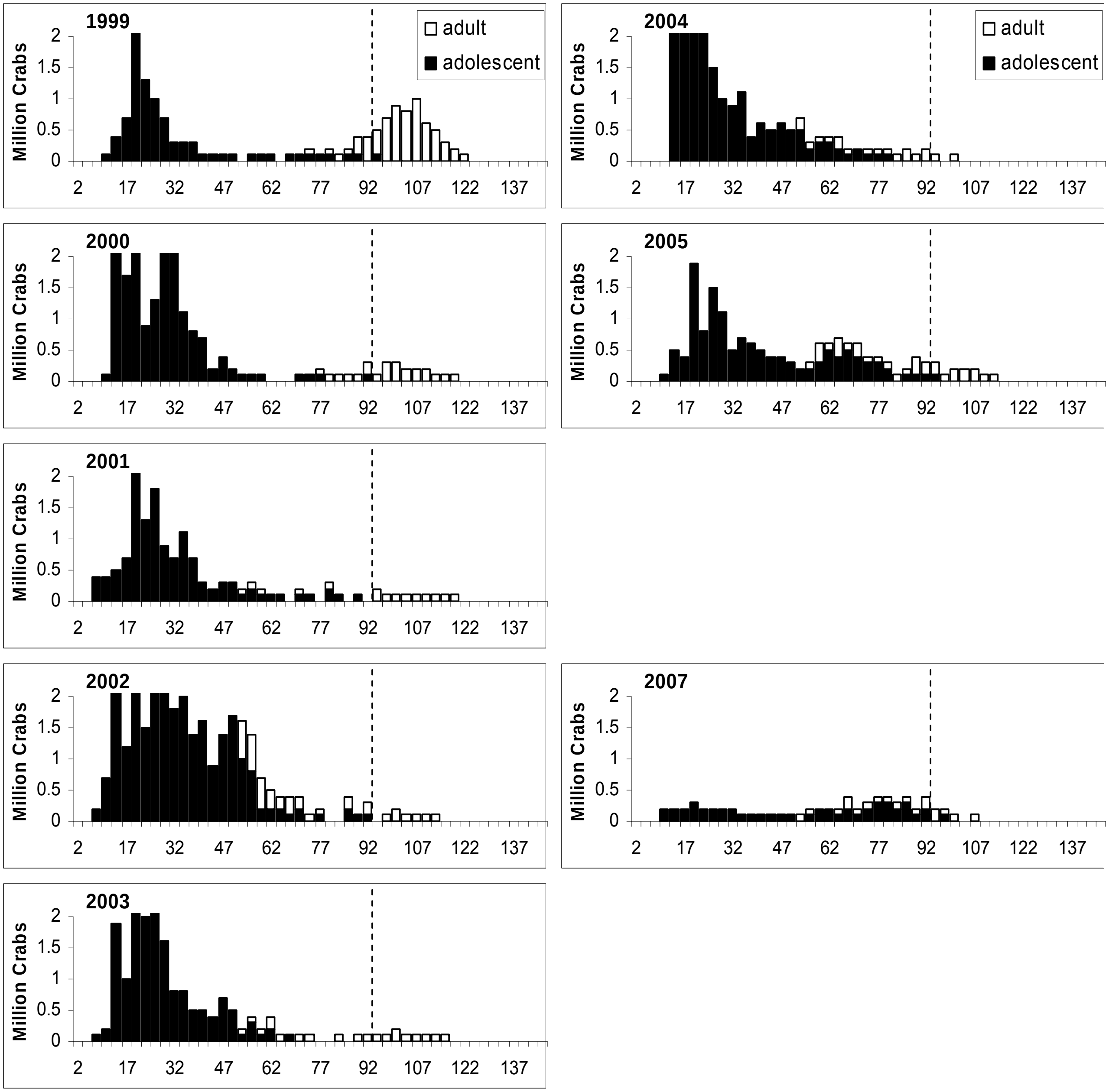


Figure 151. Distribution of abundance (index) by carapace width for Subdivision 3Ps juveniles plus adolescents (dark bars) versus adults (open bars) from spring trawl surveys. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line.

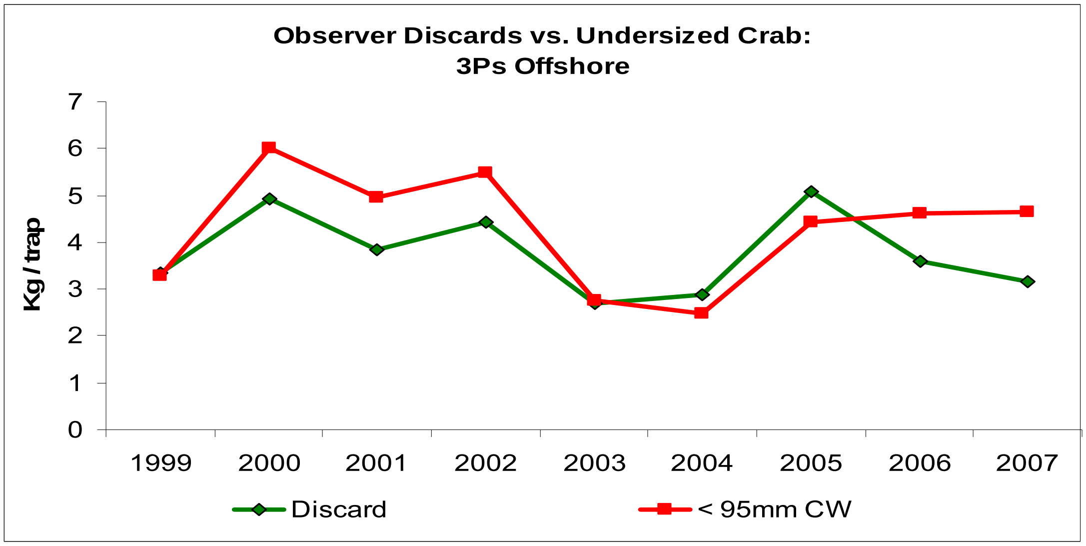


Figure 152. Trends in Subdivision 3Ps offshore observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

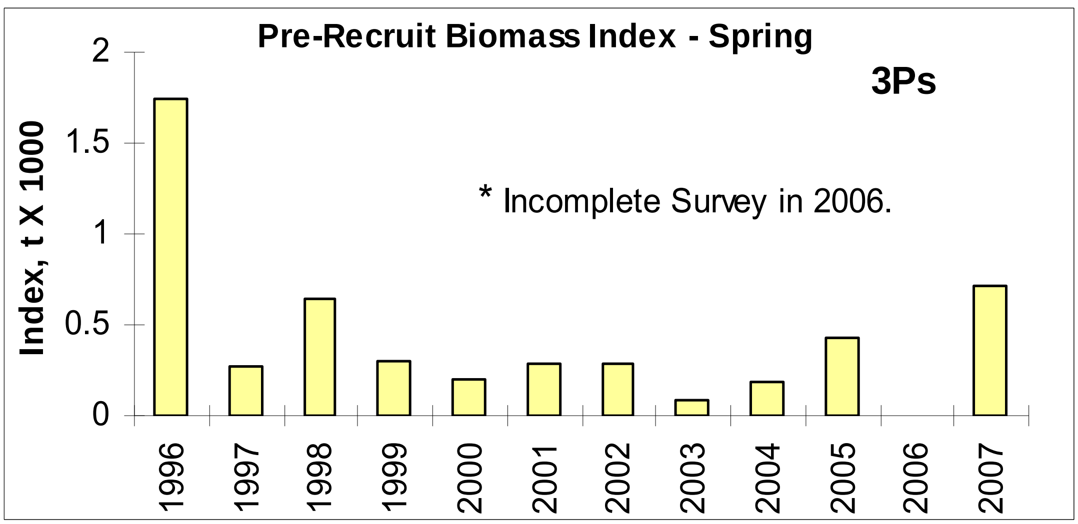


Figure 153. Trends in the Subdivision 3Ps spring trawl survey pre-recruit biomass index.

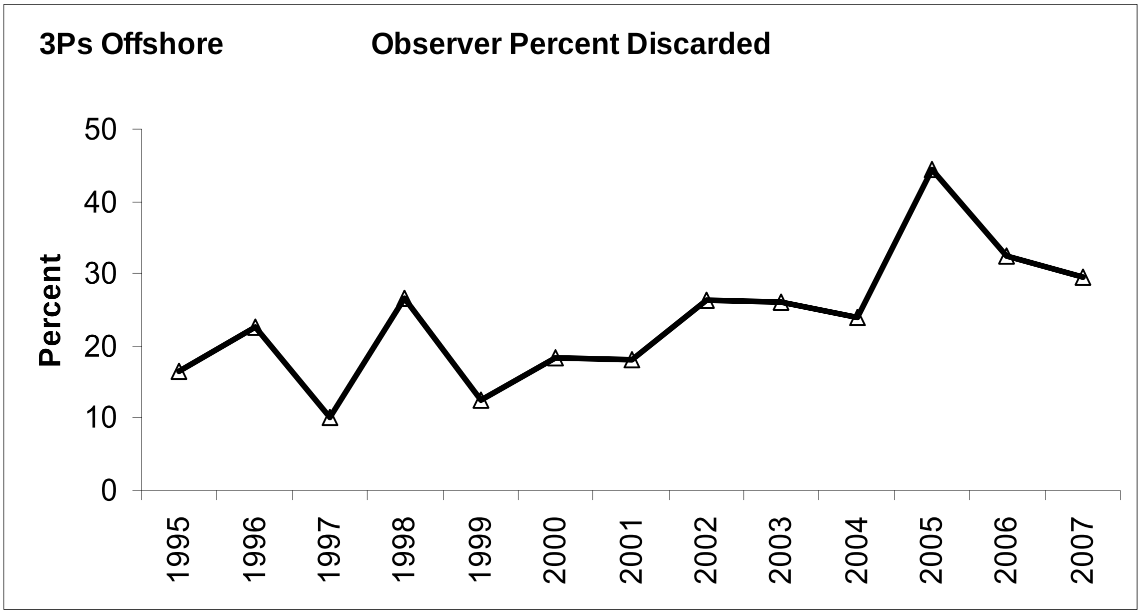


Figure 154. Trends in Subdivision 3Ps offshore percentage of the catch discarded in the fishery.

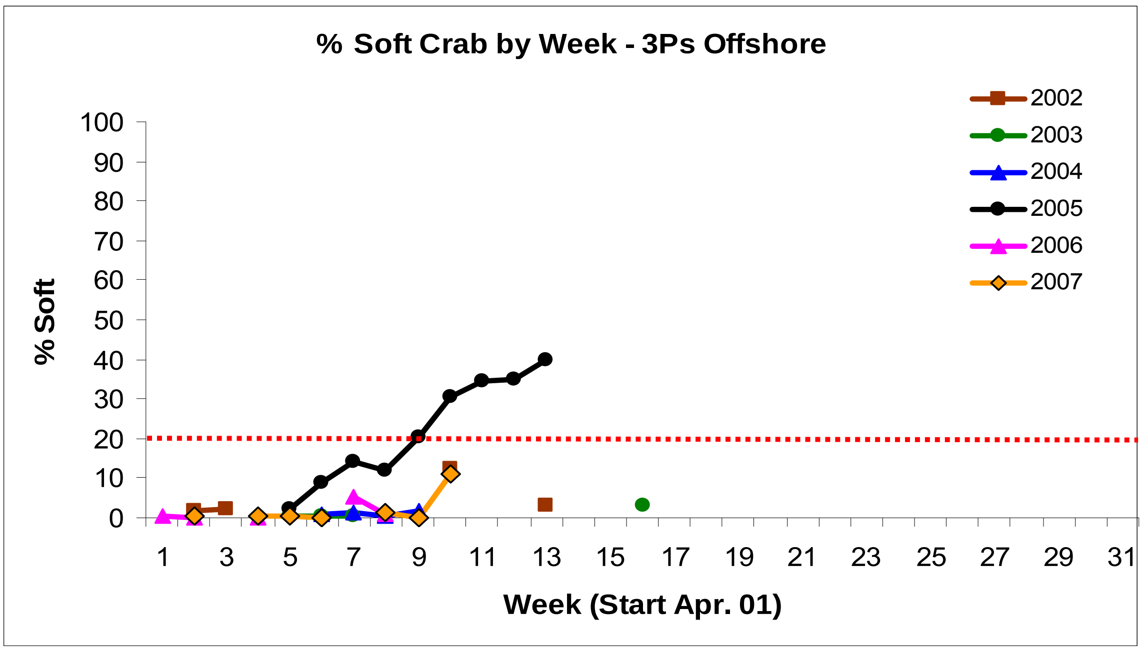


Figure 155. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the SubDivision 3Ps offshore fishery that are soft-shelled, by year (2002-07), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed.)

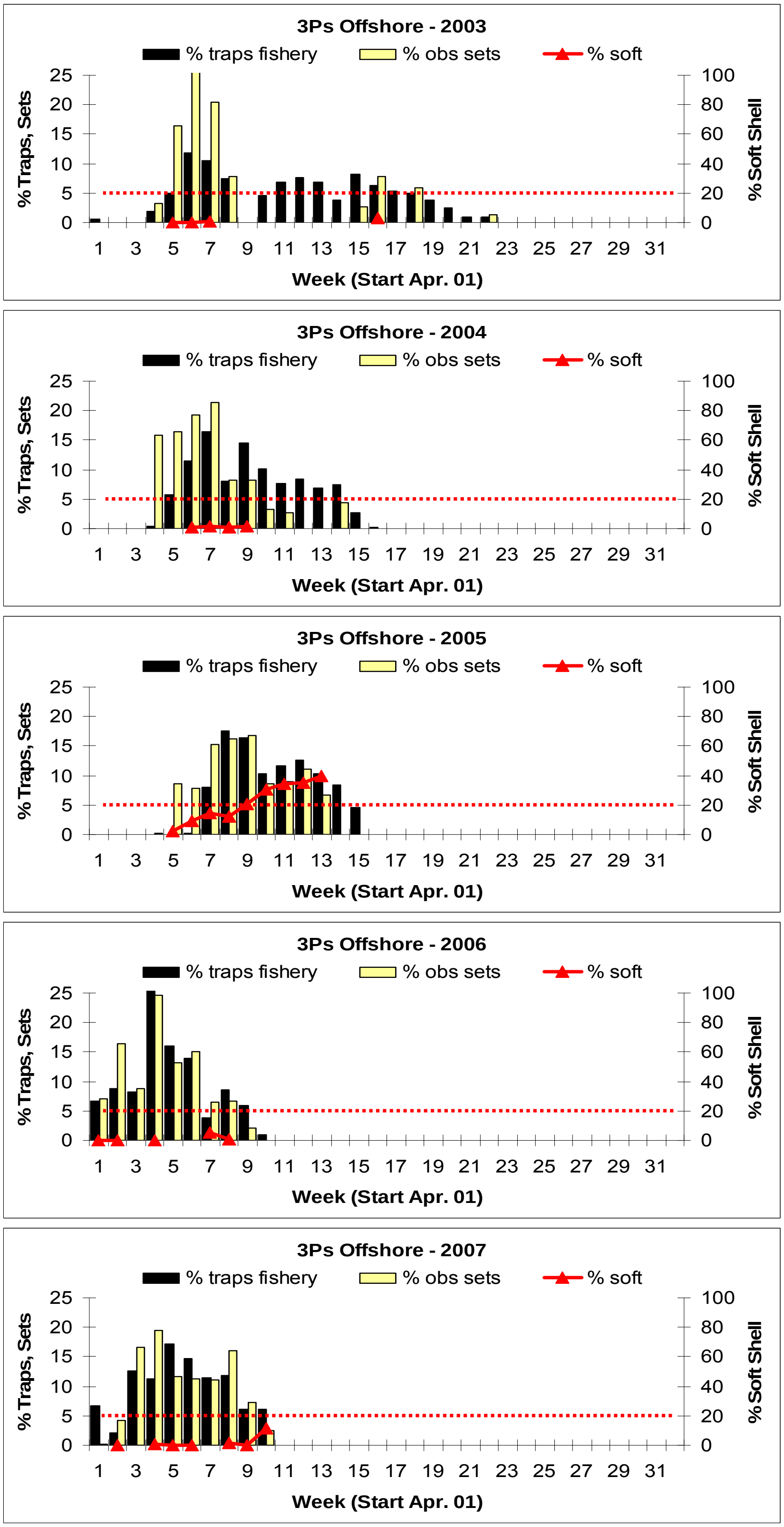


Figure 156. Seasonal trends in Subdivision 3Ps offshore distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2003-07. (Sample sizes of <10 observed sets/week removed)

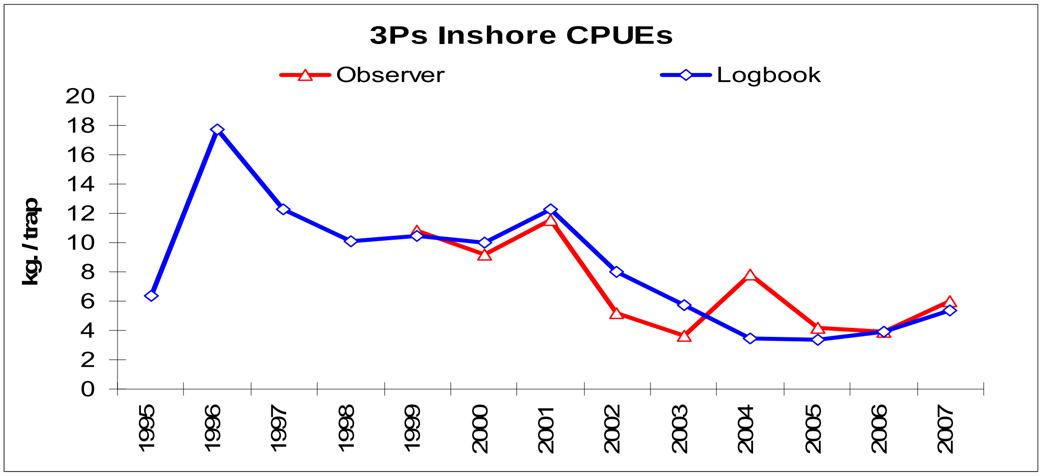


Figure 157. Trends in commercial logbook-based CPUE and observer-based CPUE in the Subdivision 3Ps inshore fishery.

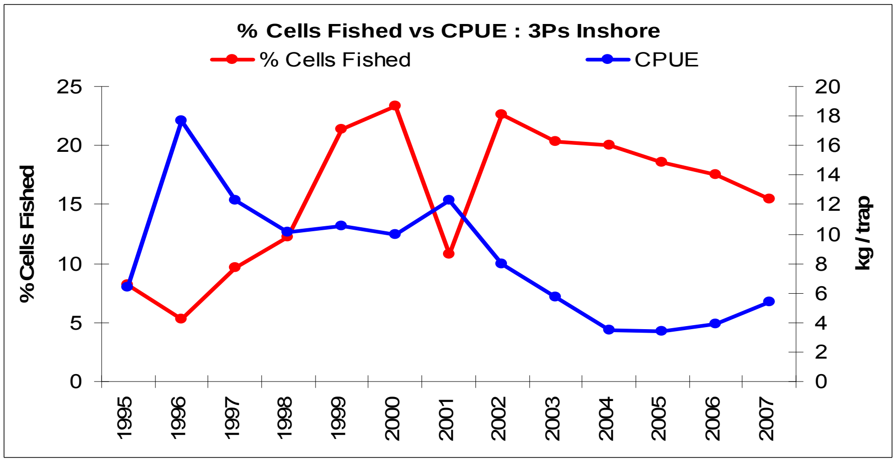


Figure 158. Trends in Subdivision 3Ps inshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

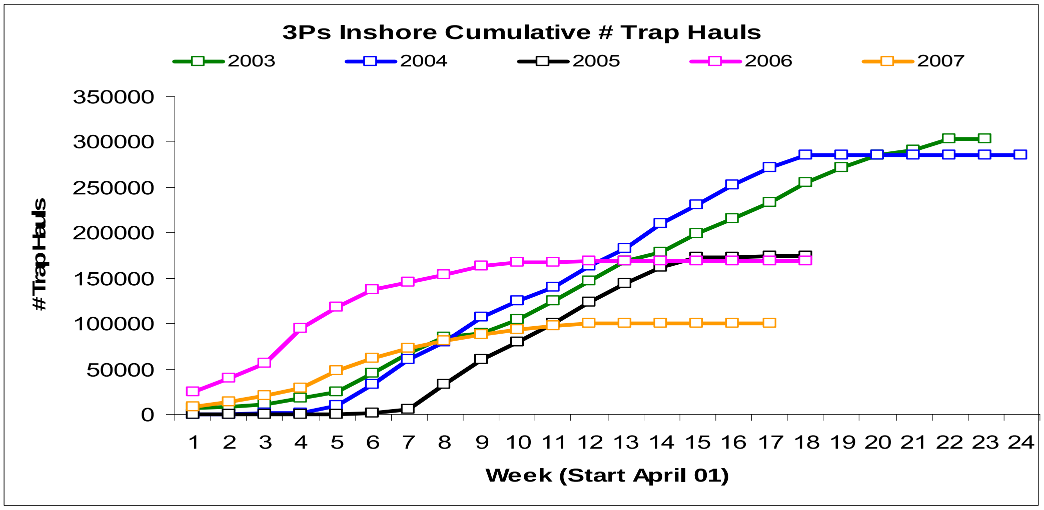
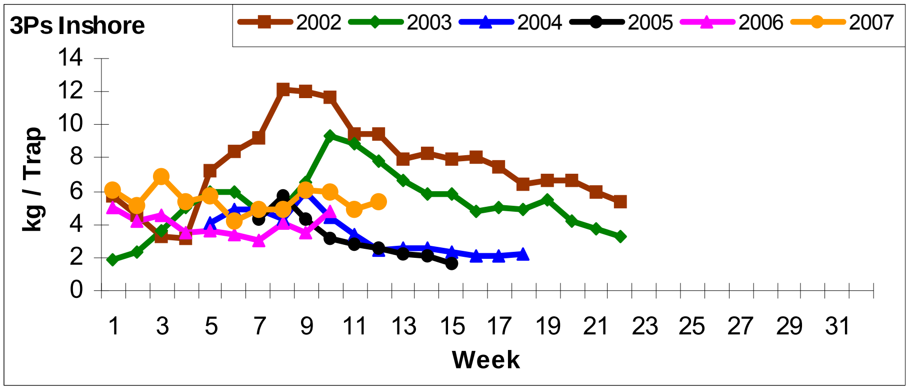


Figure 159. Seasonal trends in fishing effort for Subdivision 3Ps inshore during 2003-07.

a)



b)

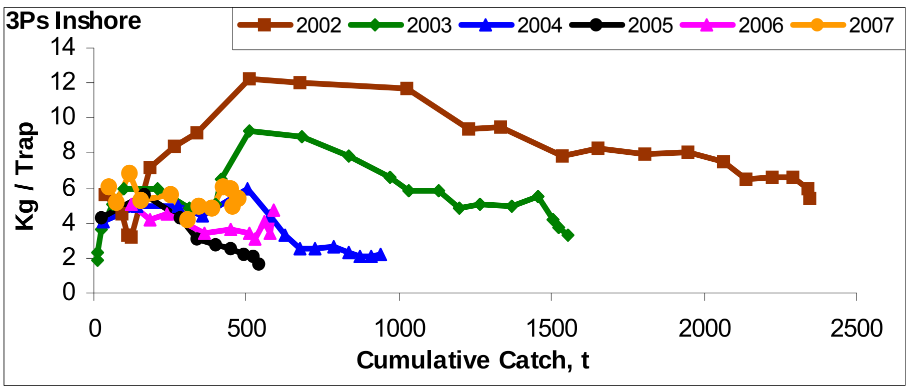


Figure 160. Seasonal trends in logbook-based CPUE for Subdivision 3Ps inshore during 2002-07; (a) by week, and (b) in relation to cumulative catch.

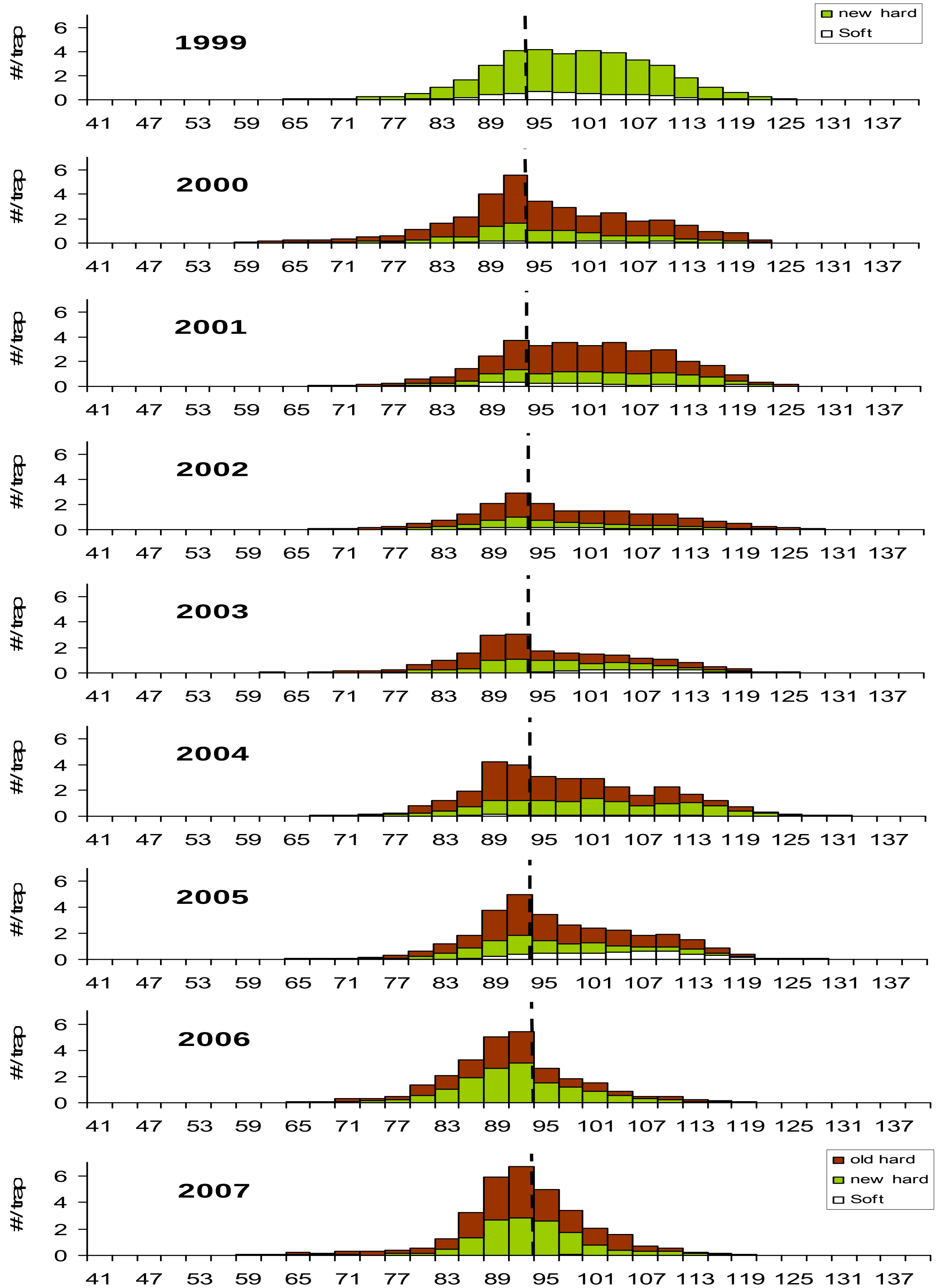
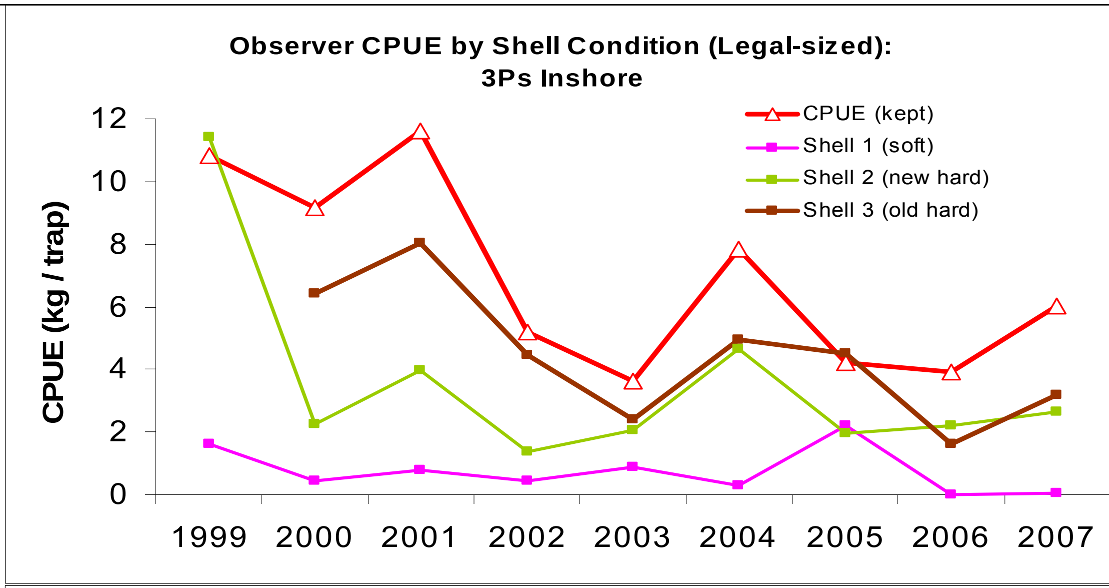


Figure 161. Trends in male carapace width distributions by shell condition from observer at-sea sampling for Subdivision 3Ps inshore. The vertical dashed line indicates the minimum legal size.

a)



b)

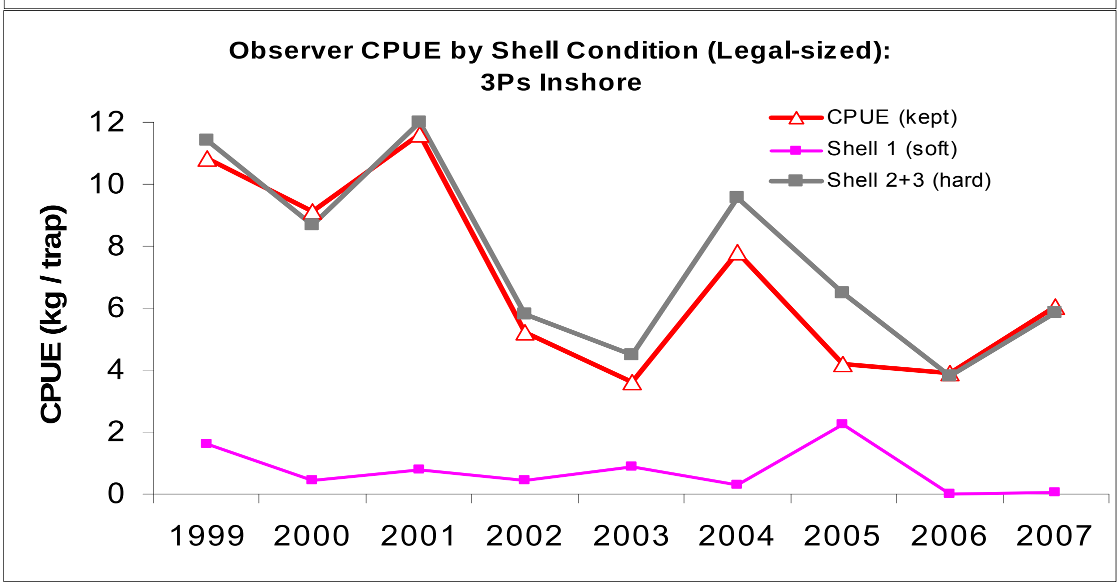


Figure 162. Trends in Subdivision 3Ps inshore observer catch rates of exploitable crabs from set and catch records (kept) and of; (a) legal-sized crabs by shell condition category from at-sea sampling, and (b) legal-sized crabs with shell conditions 2+3 combined.

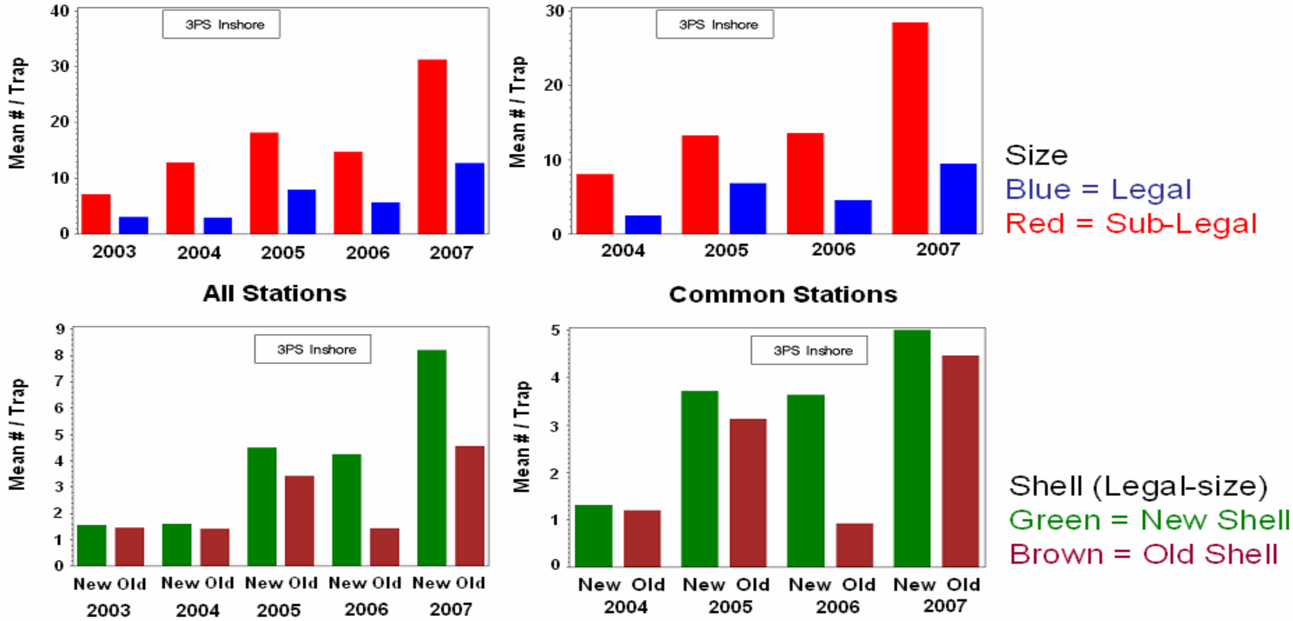


Figure 163. Trends in CPUE for size composition (above) and shell condition (below) from industry-DFO collaborative post-season trap surveys for Subdivision 3Ps inshore from all stations (left) and common stations (right).

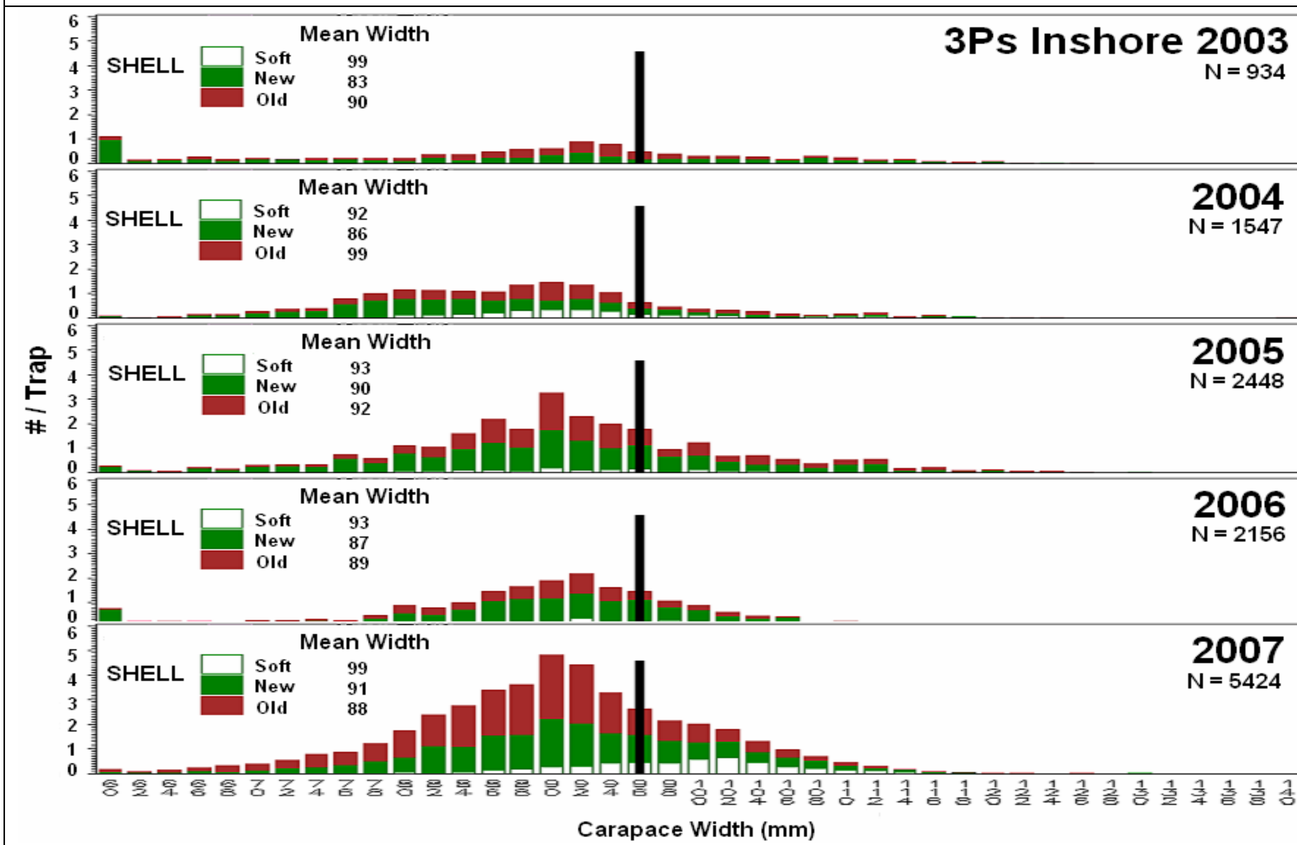


Figure 164. Trends in male carapace width distributions from industry-DFO post-season trap surveys for Subdivision 3Ps inshore (all stations). The vertical solid line indicates the minimum legal size.

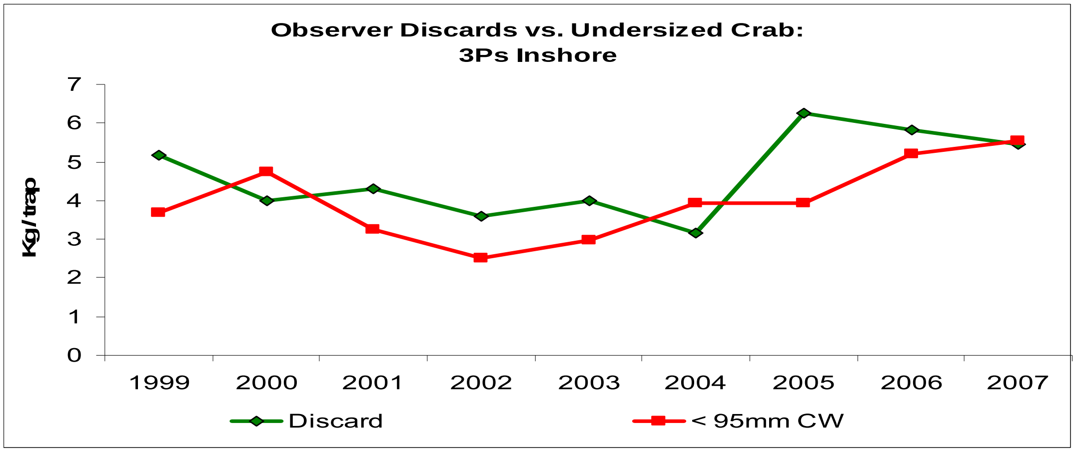


Figure 165. Trends in Subdivision 3Ps inshore observer catch rates of total discards from set and catch records and of sub-legal sized crabs from at-sea sampling.

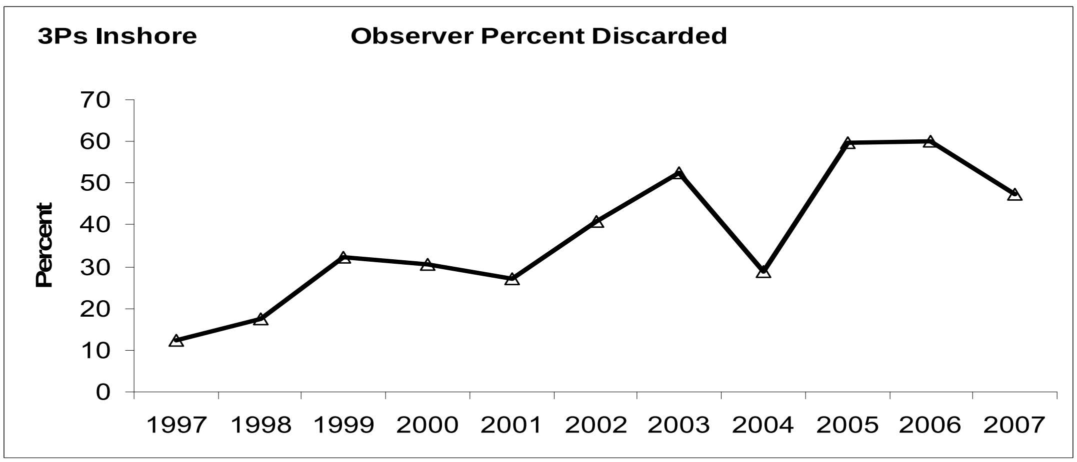


Figure 166. Trends in Subdivision 3Ps inshore percentage of the catch discarded in the fishery.

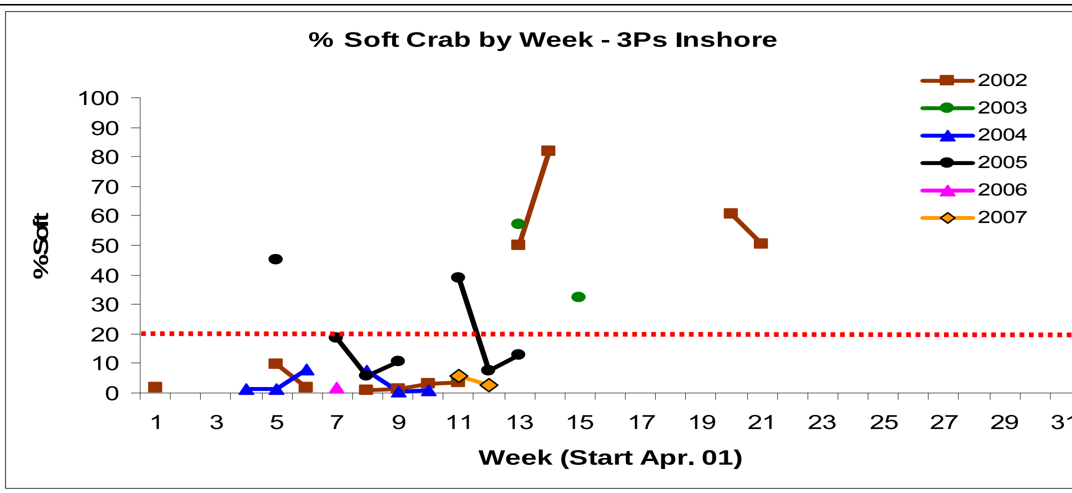


Figure 167. Seasonal trends (from April 1st) in the percentage of legal-sized crabs caught in the Subdivision 3Ps inshore fishery that are soft-shelled, by year (2002-07), from at-sea sampling by observers. (Sample sizes of <10 observed sets/week removed.)

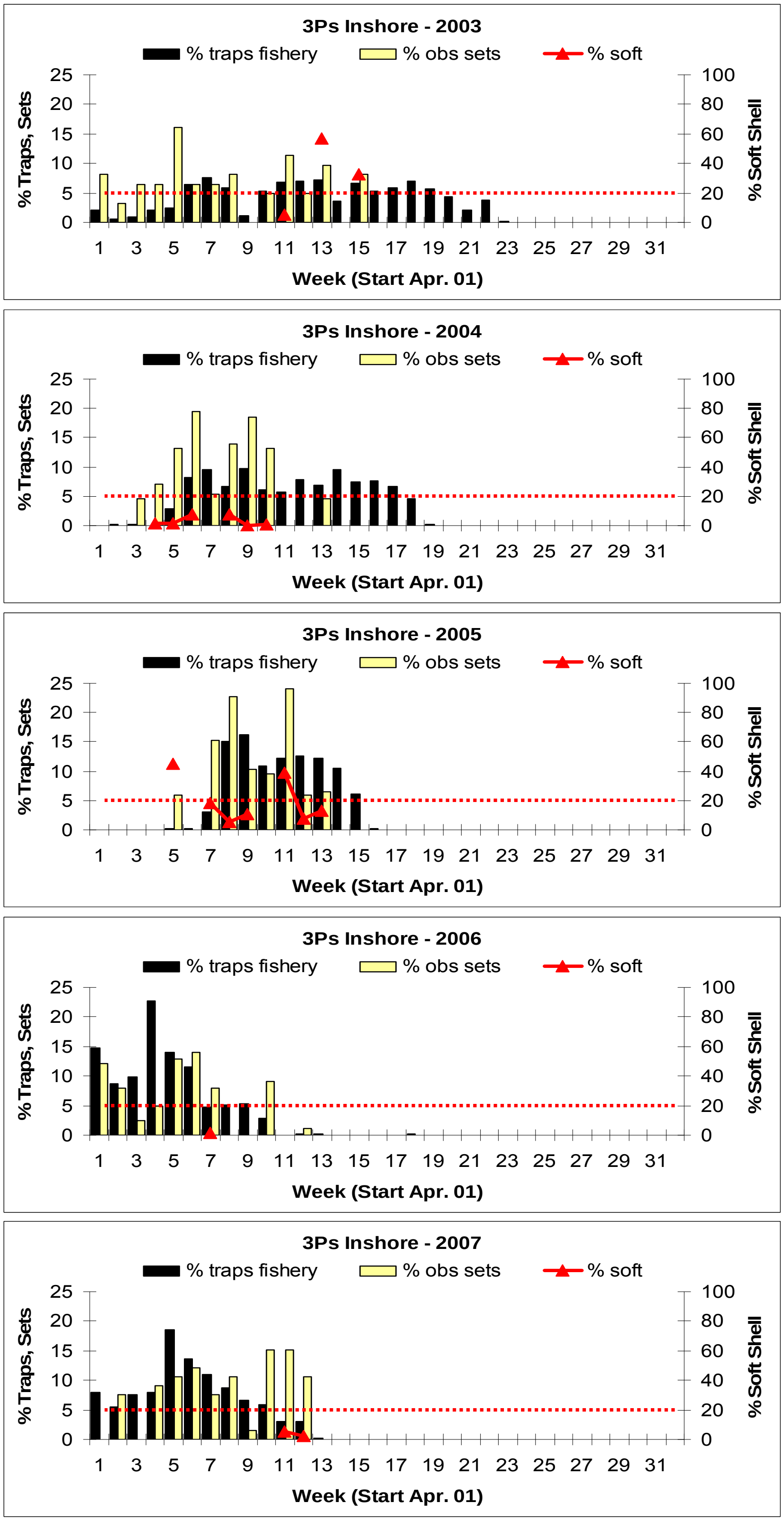


Figure 168. Seasonal trends in Subdivision 3Ps inshore distribution of total fishing effort (trap hauls) versus observed effort (sets) and of soft-shell discards during 2003-07. (Sample sizes of <10 observed sets/week removed.)

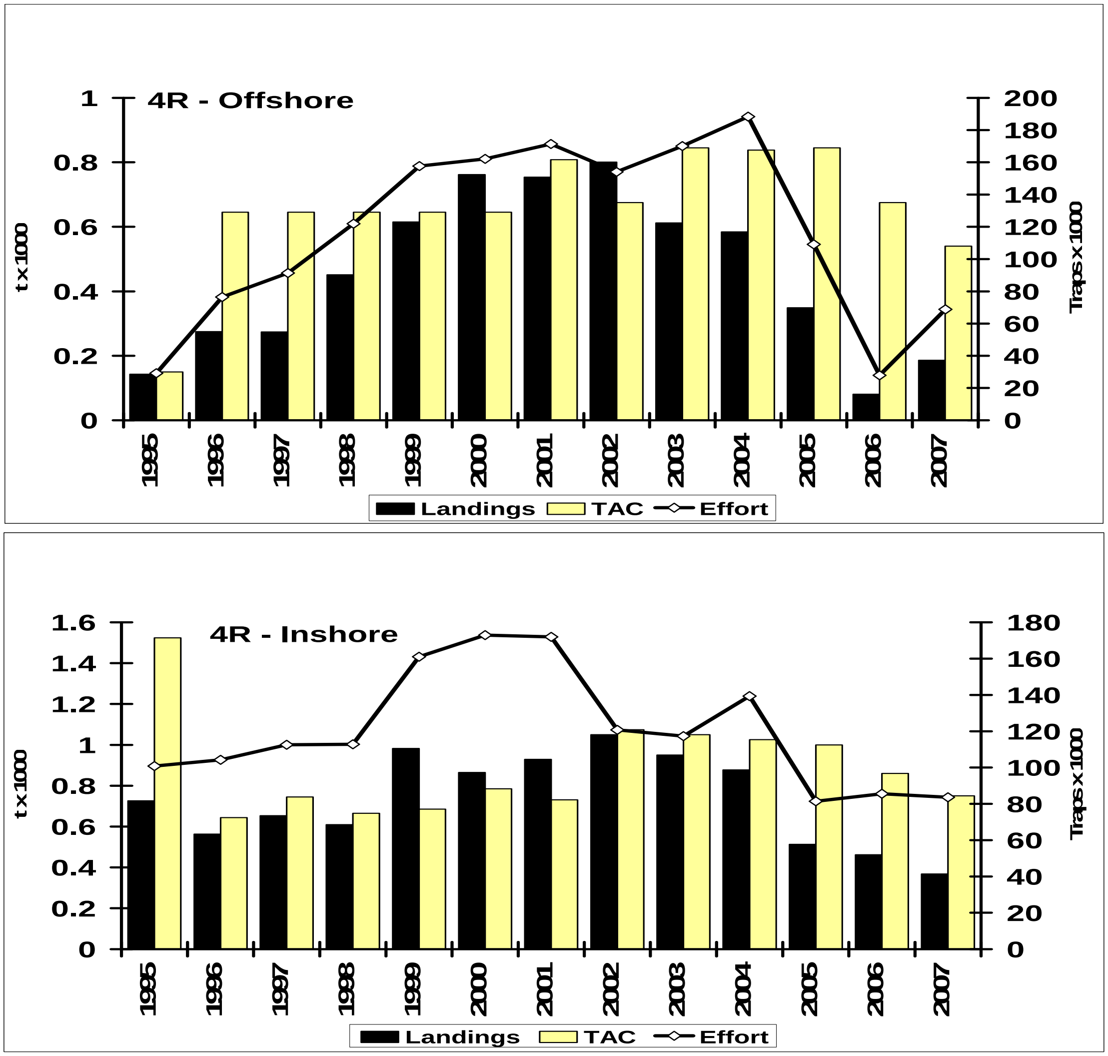


Figure 169. Trends in Divisions 4R3Pn landings, TAC, and fishing effort for the offshore (above) and inshore (below).

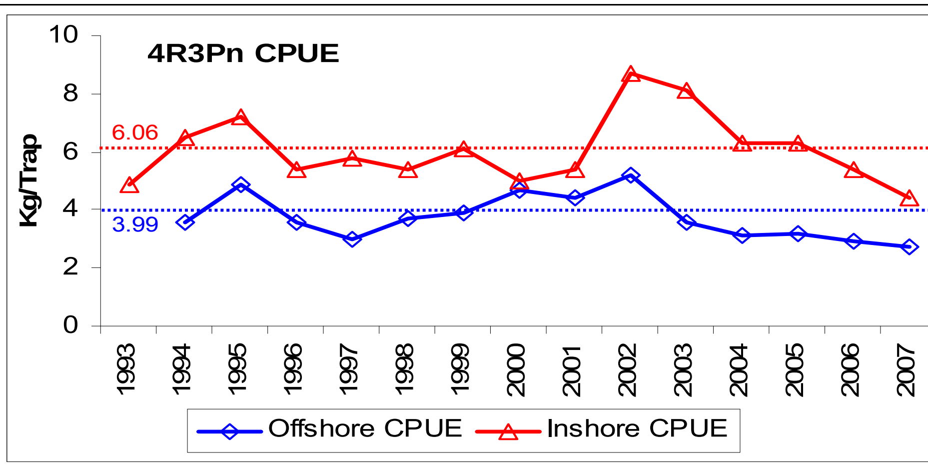


Figure 170. Trends in Divisions 4R3Pn offshore and inshore commercial CPUE in relation to their long-term averages (dotted lines).

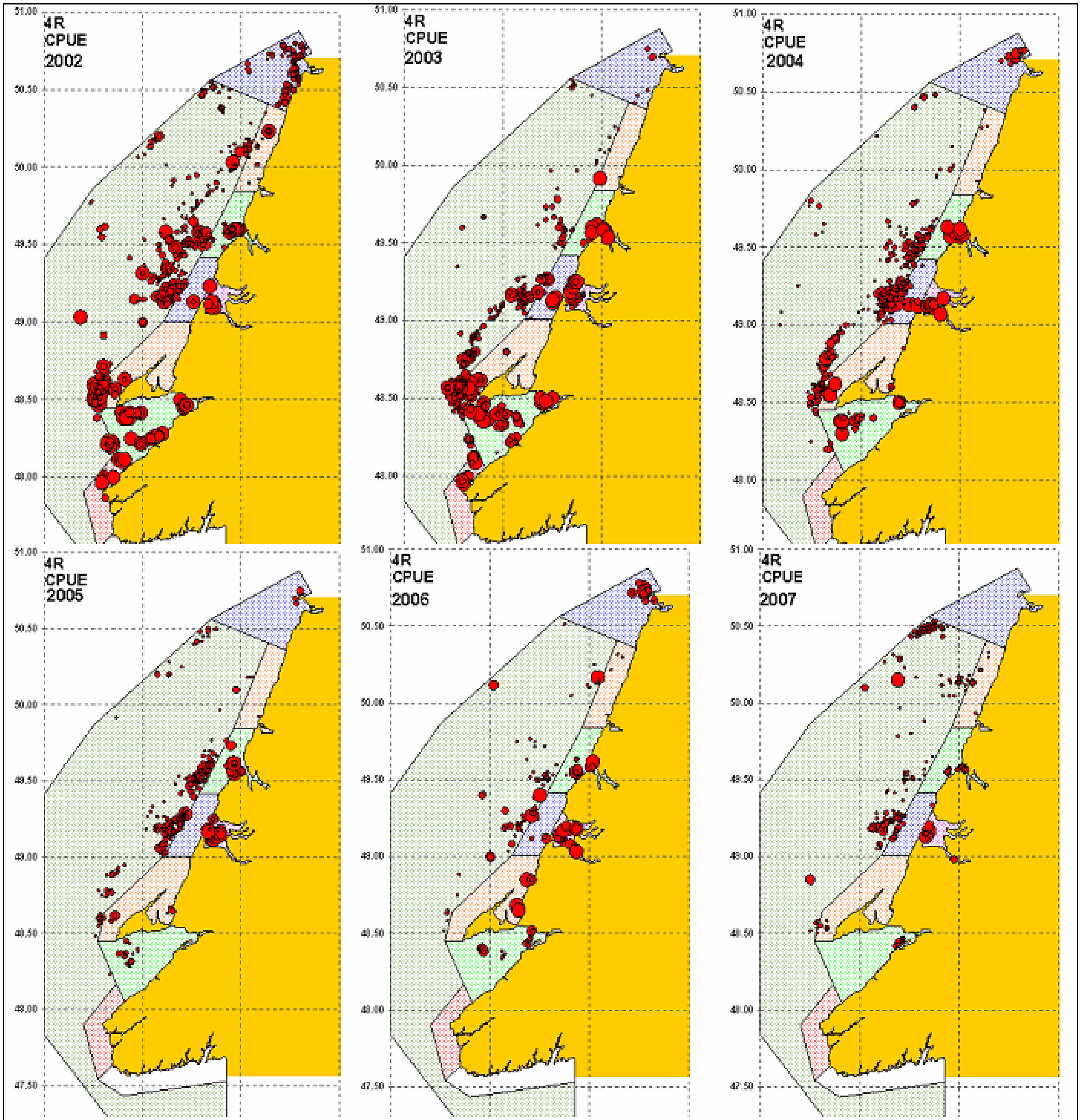


Figure 171. Spatial distribution of Divisions 4R3Pn commercial CPUE by year.

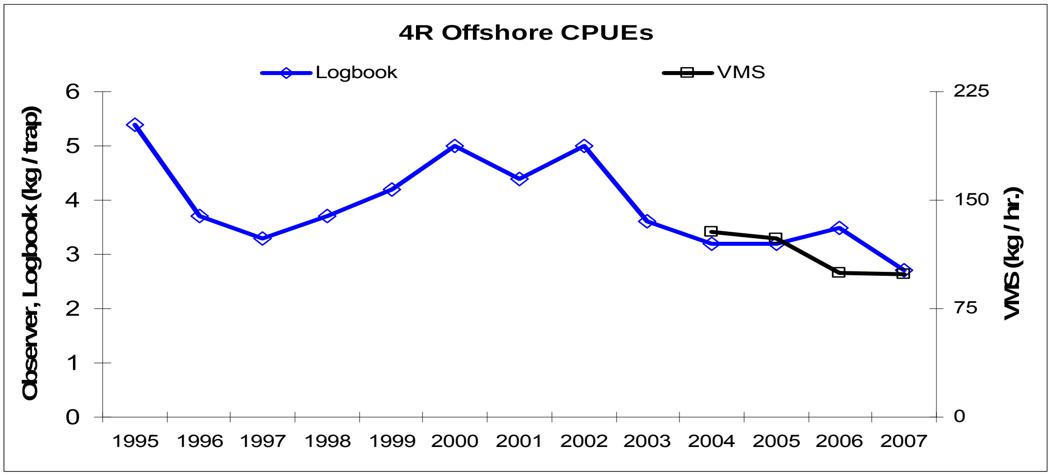


Figure 172. Trends in commercial logbook-based CPUE and VMS-based CPUE in the Divisions 4R3Pn offshore fishery.

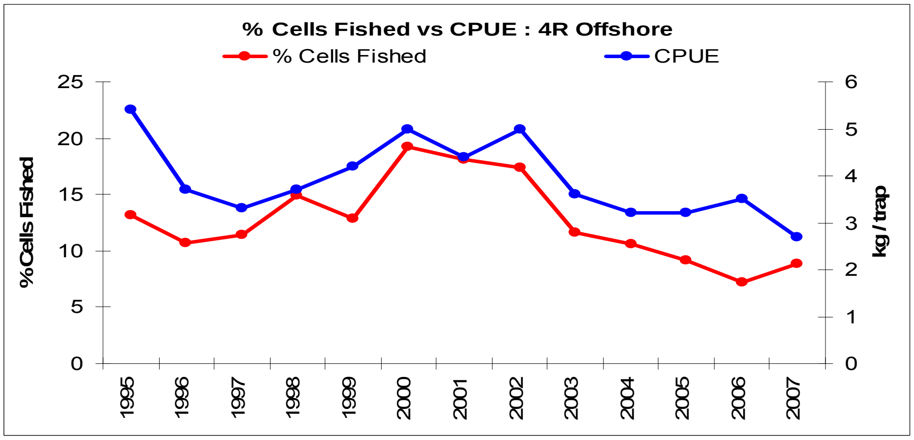


Figure 173. Trends in Divisions 4R3Pn offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

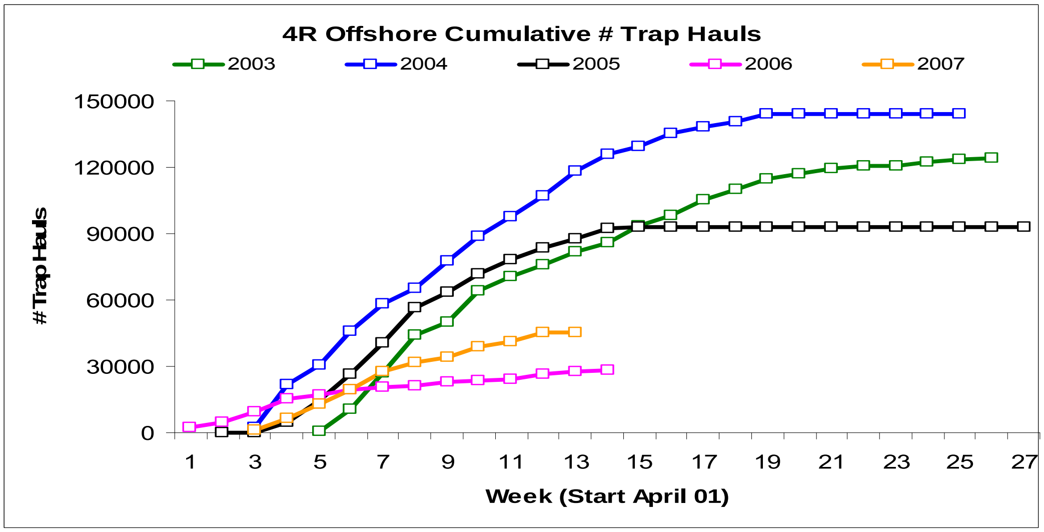


Figure 174. Seasonal trends in fishing effort for Divisions 4R3Pn offshore during 2003-07.

a)

b)

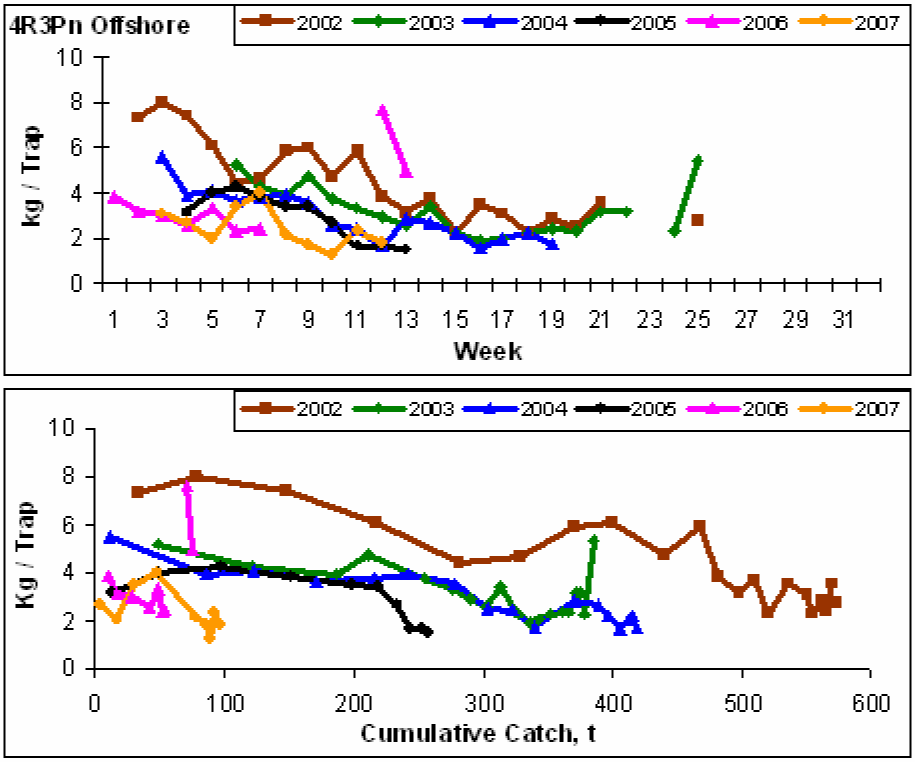


Figure 175. Seasonal trends in logbook-based CPUE for Divisions 4R3Pn offshore during 2002-07; (a) by week, and (b) in relation to cumulative catch.

a)

b)

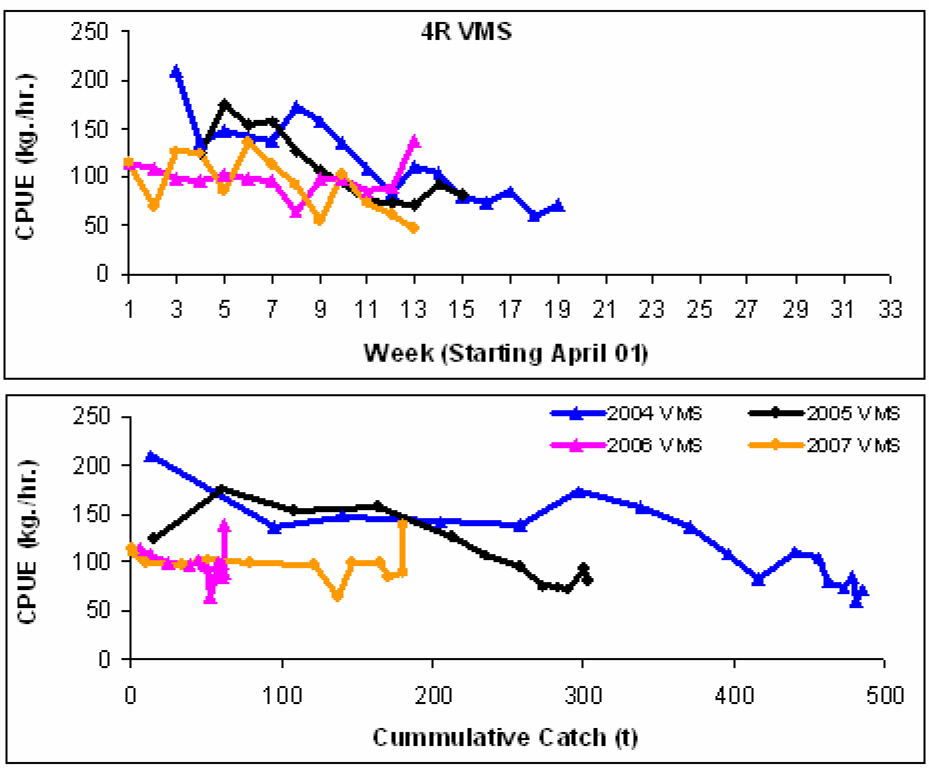


Figure 176. Seasonal trends in VMS-based CPUE for Divisions 4R3Pn offshore during 2002-07; (a) by week, and (b) in relation to cumulative catch.

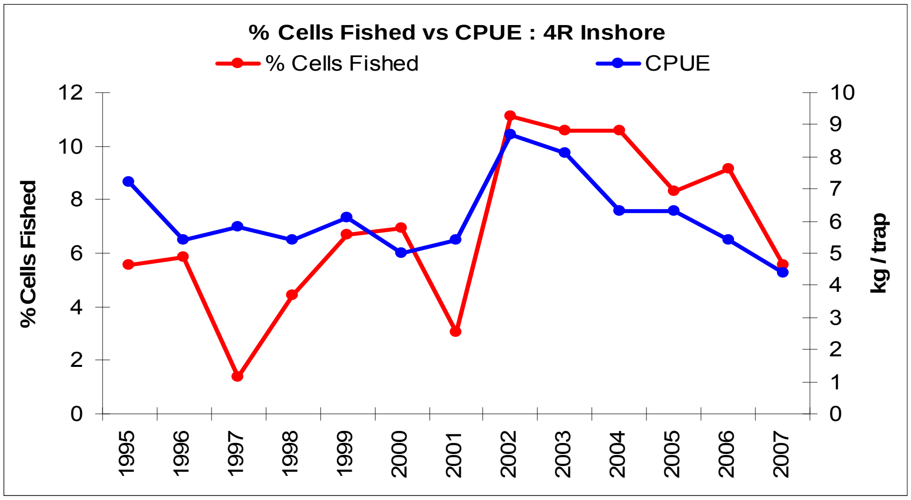


Figure 177. Trends in Divisions 4R3Pn inshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

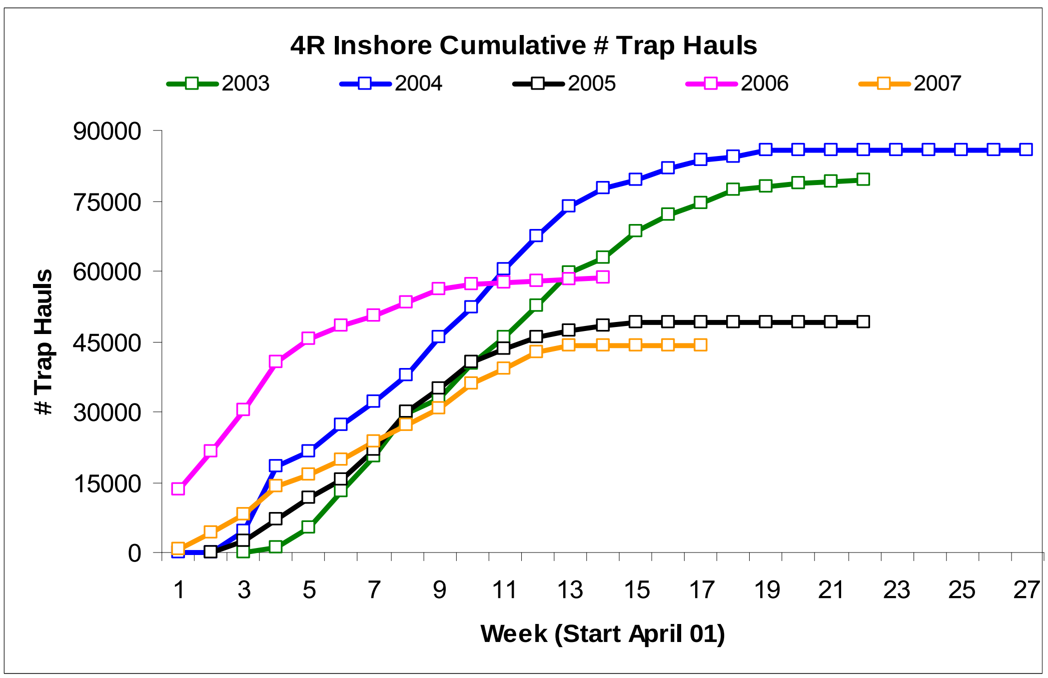


Figure 178. Seasonal trends in fishing effort for Divisions 4R3Pn inshore during 2003-07.

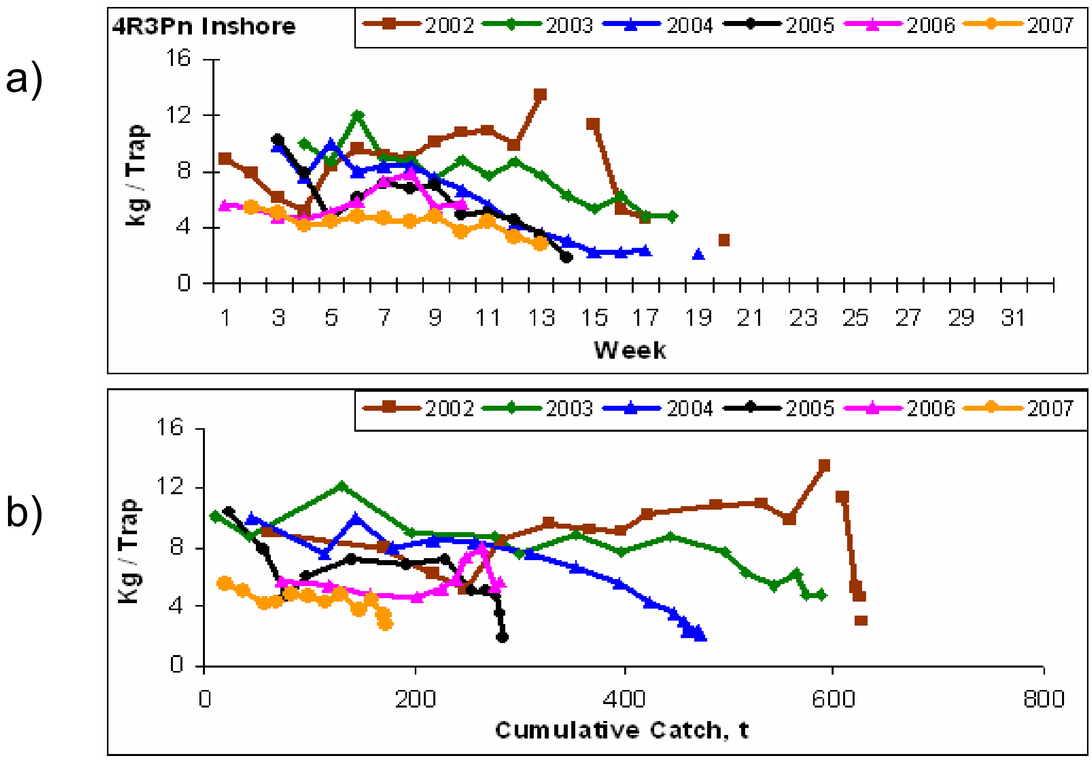


Figure 179. Seasonal trends in logbook-based CPUE for Divisions 4R3Pn inshore during 2002-07; (a) by week, and (b) in relation to cumulative catch.

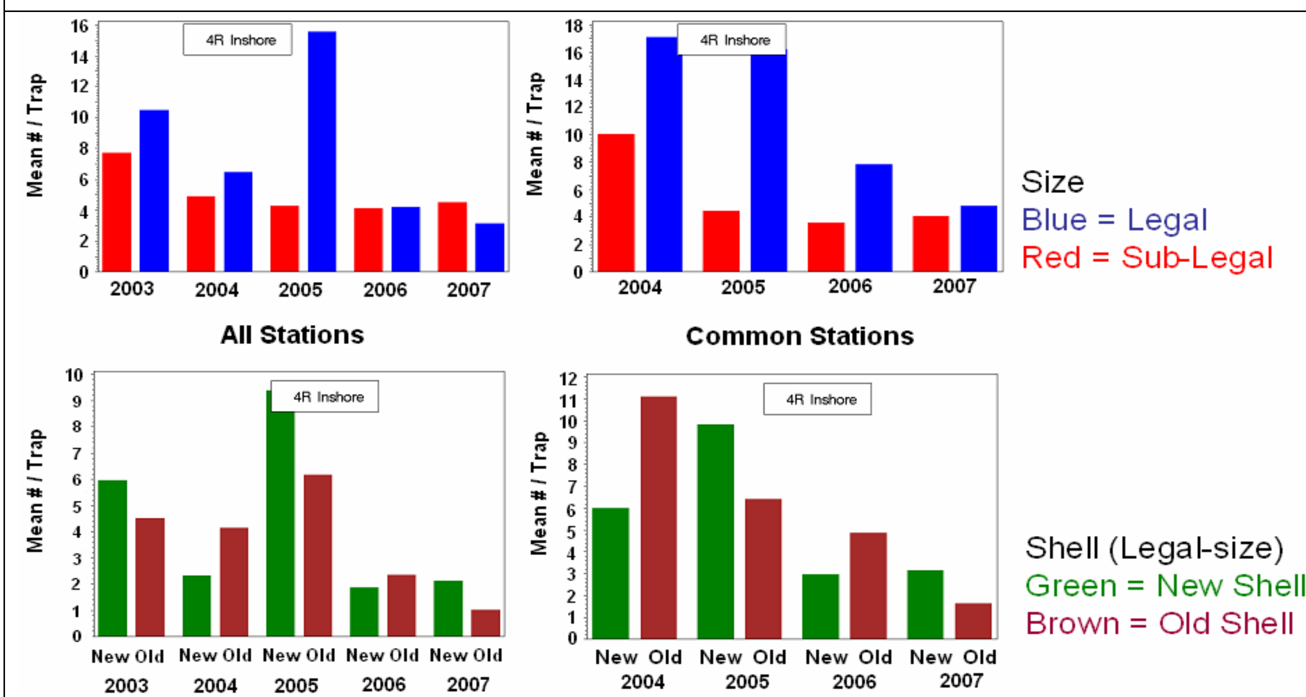


Figure 180. Trends in CPUE for size composition (above) and shell condition (below) from industry-DFO collaborative post-season trap surveys for Divisions 4R3Pn inshore from all stations (left) and common stations (right).