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**An Assessment of Newfoundland and Labrador Snow Crab
(*Chionoecetes opilio*) in 2012**

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Foreword

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

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ABSTRACT

Resource status was evaluated throughout the Northwest Atlantic Fisheries Organization (NAFO) Divisions (Div.) 2HJ3KLNOP4R based on trends in biomass, recruitment, production, and mortality. Multiple indices of these metrics were derived from a suite of data sources that include dockside-monitored landings, harvester logbooks, at-sea 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 and oceanographic sampling data from multiple sources. The resource was assessed separately for offshore and inshore areas of each NAFO Division, where appropriate (Div. 3KLP4R). Data availability varied among divisions and between inshore and offshore areas within divisions. The multi-species trawl surveys indicate that the exploitable biomass declined from 2008 to 2011 and was unchanged in 2012. The trawl surveys indicate that recruitment has recently declined and is expected to decline further in the short term (2-3 years). Long-term recruitment prospects are unfavourable due to a recent warm oceanographic regime. 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.

**Évaluation du stock de crabes des neiges (*Chionoecetes opilio*)
de Terre-Neuve-et-Labrador en 2012**

RÉSUMÉ

L'état de la ressource dans les divisions 2HJ3KLNOP4R de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO) a été évalué en fonction des tendances relatives à la biomasse, au recrutement, à la production et à la mortalité. Les indices multiples de ces paramètres proviennent d'une série de sources de données, notamment des débarquements faisant l'objet d'une vérification à quai, des journaux de bord des pêcheurs, de la surveillance en mer effectuée par des observateurs, des relevés au chalut avant et après la saison de pêche, des relevés au casier à grande échelle après la saison de pêche, des relevés au casier localisés dans les eaux côtières, du Système de surveillance des navires et des données d'échantillonnage biologiques et océanographiques tirées de sources multiples. L'état du stock des zones extracôtières et des zones côtières de chaque division de l'OPANO a été évalué séparément, lorsque cela était approprié (division 3KLP4R). La disponibilité des données varie en fonction des divisions ainsi qu'en fonction des zones du large et côtières à l'intérieur des divisions. Les relevés plurispécifiques au chalut montrent que la biomasse exploitable a diminué de 2008 à 2011 et est restée stable en 2012. Les relevés au chalut montrent que le recrutement a récemment connu une baisse et devrait continuer à diminuer à court terme (deux à trois ans). Les perspectives de recrutement à long terme sont pessimistes en raison d'un régime océanographique récemment chaud. On décrit en détail les tendances relatives aux indices pour chaque division et on présente des conclusions en ce qui concerne les effets prévus qu'auraient des changements à court terme dans les niveaux de prélèvement sur la mortalité par la pêche.

INTRODUCTION

This document serves to assess the status of the snow crab (*Chionoecetes opilio*) resource surrounding Newfoundland and Labrador (NL) in NAFO Divisions 2HJ3KLNOP4R. The information presented follows from a formal scientific assessment conducted during February 2013, focused upon determining changes in the exploitable biomass of crabs available to the 2013 fishery (commencing in April 2013), as well as to the fisheries of succeeding years.

Snow crab are sexually dimorphic, with males normally achieving larger sizes than females. Exploitable crabs consist of large males that have not molted within the past 6-12 months, as recently-molted animals do not yield commercially acceptable meat content. Production of snow crab is largely environmentally driven, with cold temperatures during early life history favouring increased recruitment (Marcello et al. 2012). Growth rates are also affected by temperature, with age-at-recruitment older within a cold regime than within a warm regime due to a lower frequency of molting in cold conditions (Dawe et al. 2012a). The minimum legal size is 95 mm carapace width (CW). This regulation excludes females from the fishery and ensures a portion of the adult males remain available for reproduction.

Snow crab in NL are part of a larger population in Canadian Atlantic waters, ranging from southern Labrador to the Scotian Shelf (Puebla et al. 2008). However, as movements of individuals within the stock are thought to be limited, assessments are conducted at the NAFO Division level (Fig. 1) with inshore and offshore areas considered separately where applicable. This is intended to partially conform with crab management areas (CMAs) (Fig. 2) while accommodating different types and amounts of available information.

The NL snow crab fishery began in 1967 and was limited to NAFO Divisions 3KL until the mid-1980s. It has since expanded throughout Divisions 2HJ3KLNOP4R and is prosecuted by several fleet sectors. Management of the increasingly diverse fishery led to the development of many quota-controlled areas with about 3100 licence/permit holders under enterprise allocation in 2012. The fishery is prosecuted using conical baited traps set in long-lines ('fleets'). The minimum legal mesh size is 135 mm to allow small crabs to escape. Under-sized and soft-shelled crabs that are captured in traps are returned to the sea and an unknown proportion of those die.

Data from multi-species bottom trawl surveys, conducted during fall in Div. 2HJ3KLNO, spring in Subdiv. 3Ps, and summer in Div. 4R, are examined to provide information on trends in biomass, recruitment, production, and mortality over the time series. Multi-species trawl survey indices are compared with other relevant indices derived utilizing data from harvester logbooks, at-sea observers, VMS, the dockside monitoring program (DMP), and inshore and offshore trap surveys, as well as oceanographic surveys toward inferring changes in resource status for 2013 and beyond.

The snow crab resource declined during the early 1980s but recovered and remained very large throughout the 1990s. The multi-species trawl surveys indicate that both the exploitable and pre-recruit biomass have recently declined and recruitment is expected to decline further in the short-term. Long-term recruitment prospects are unfavourable due to a warming oceanographic regime. Declines in the exploitable biomass have already occurred in the northernmost areas and there are concerns of a forthcoming decline in the more productive southern areas.

METHODOLOGY

MULTI-SPECIES TRAWL SURVEY DATA

Data on total catch numbers and weights were derived from multi-species bottom trawl surveys (Fig. 3) conducted during fall in Div. 2HJ3KLNO, spring in Subdiv. 3Ps, and summer in Div. 4R. The trawl used in the spring and fall surveys was changed to a Campelen 1800 shrimp trawl in 1995, and this trawl proved to be more efficient in sampling crabs than the previously used groundfish trawl. The fall post-season trawl survey was conducted annually in all divisions except Div. 2H, where it was executed annually from 1996-99, bi-annually from 2004-08, and annually from 2010-12. Snow crab sampling during spring Div. 3LNOPs surveys did not begin until 1996, and data were only available from summer trawl surveys conducted in Div. 4R since 2004. The catchability of the survey trawl differs by season; spring (pre-fishery) trawl surveys are considered to be the least reliable because some population components are relatively poorly sampled when mating and molting take place, while the fall trawl surveys are thought to have the highest catchability for snow crabs. Prior to 2009, survey abundance and biomass indices were calculated based on a set of common strata that were sampled in all years for each seasonal survey and NAFO Division. Due to gradual attrition of common strata over time, a set of "core strata" was selected in 2009 and used for the assessment since (Fig. 3). This core group included strata most consistently sampled throughout the time series, capturing strata that were common to most years, especially recent years, and does not include inshore strata or deep (>730 m) slope edge strata that have not been regularly sampled. For the summer trawl survey in Div. 4R, all strata occurring within the offshore management area were used to calculate abundance and biomass indices as that survey has suffered less from the attrition of strata over time, although some of the southern strata not considered to represent crab habitat were missed in 2010. The 2004 and 2006 Div. 3L fall surveys, and the 2006 Div. 3NOPs spring survey were incomplete and have 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 due to higher trawl catchability.

Snow crab catches from each survey set were sorted, weighed, and counted by sex. Catches were sampled in their entirety or sub-sampled by sex. Sampling of individual crabs of both sexes included determination of CW and (except Div. 4R) shell condition. 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 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 final (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 may be retained by the fishery if it extends late into the season. It is assumed that all males with small chelae molt each spring and so remain new-shelled between molts. In reality, however, an annually variable proportion of small-clawed males will not molt in any given year ('skip molters') and so will develop 'older shells' between molts. For each year that a crab skips a molt, its eventual recruitment is delayed by a year. Skip-molting is most common in large adolescent males in cold areas (Dawe et al. 2012a).

Males were also sampled for chela height (CH) (0.1 mm). Males develop enlarged chelae when they undergo their terminal 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:

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

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), a fatal affliction, 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 (ie. 'blood') 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 immediate pre-recruits 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.

Biomass and abundance indices were calculated from spring and fall surveys using STRAP (Smith and Somerton 1981), to represent the exploitable and pre-recruit biomass for males and the abundance of mature females. For spring (pre-season) surveys, these indices represent biomass for the immediately upcoming, or on-going, fishery whereas for summer and fall (post-season) surveys the indices represent biomass for the 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 immediate or upcoming fishery but would be fully recruited to the fishery in the following year. The offshore exploitable biomass for Div. 4R was calculated based strictly on size, as data on shell condition and CH are not recorded during these summer trawl surveys. Stations within inshore Div. 4R CMAs and CMA 13 (assessed by Fisheries and Oceans Canada (DFO) Quebec Region) were rejected in calculating biomass indices for offshore Div. 4R.

The pre-recruit biomass 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). The pre-recruit biomass index for Div. 4R was calculated based strictly on size, thus it contains an unknown proportion of sub-legal-sized adult crabs that will never recruit to the fishery. The abundance of mature females could not be calculated for the summer trawl survey in Div. 4R due to the unavailability of maturity data from that survey so a proxy of females ≥ 30 mm CW was used as an index of reproductive potential.

The exploitable and pre-recruit biomass indices and the mature female abundance 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. 2010a). 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 skip-molters in the following spring. It is assumed that all small-clawed males molt each year. The spatial distribution of pre-recruit and exploitable biomass was examined using catch rates (numbers per tow) for each survey set.

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 provide a useful indication of trends in exploitation rates. Inshore commercial catches and data from inshore survey strata in Div. 2HJ3KLNOP were not included in calculating the ratios because inshore survey strata were not surveyed in all years. In Div. 4R, inshore strata have been consistently surveyed in some bays, and the catches from these strata have been removed from offshore indices.

To examine size composition of males, trawl survey catches by carapace width were grouped into 3 mm CW intervals and adjusted to reflect total population abundance indices. In Div. 2HJ3KLNOP, each size interval was partitioned, based on chela allometry, between juveniles plus adolescents (small-clawed) versus adults (large-clawed).

To investigate the possible effect of thermal regime on snow crab production or early survival we compared trawl survey exploitable biomass indices with lagged (lag of best fit) thermal indices for offshore areas in each of Divisions 2J, 3K, 3LNO (as a group) and Subdiv. 3Ps. Fishery Catch per Unit Effort (CPUE) indices are correlated with exploitable biomass indices from the trawl surveys and provide longer time series, thus similar comparisons were made between thermal habitat indices and fishery CPUE indices. We used two indices of thermal regime, mean bottom temperature and area of cold bottom water distribution (snow crab thermal habitat index). Bottom temperatures used were from shallow strata in each division (<200 m in Div. 2J and 4R, <300 m in 3K and <100 m in Div. 3LNOPs) because settlement of early benthic stages occurs primarily in shallow areas, inshore and on banks (Dawe and Colbourne 2002). The thermal habitat index was calculated as the percentage of the area surveyed that was covered by cold water of <2 °C in Div. 2J3K, <0 °C in Div. 3LNO and <1 °C in Subdiv. 3Ps. No thermal habitat index was calculated for Div. 4R due to insufficiency of data. Mean bottom temperatures and thermal habitat indices for Div. 2J3K were derived using data from fall surveys, whereas those from Div. 3LNOPs were derived using data from spring surveys and year-round data from Station 27, a frequently sampled oceanographic station located 10 nm off St. John's, Newfoundland.

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, DFO Newfoundland and Labrador Region. CPUE (kg/trap haul) was calculated by year and NAFO division, and by CMA where applicable. Catch per Unit Effort is used as an index of biomass, but it is unstandardized in that it does not account for variation in fishing practices (eg. soak time and mesh size). However, raw CPUE has been shown to trend similarly to

standardized and modeled CPUE that incorporate these variables (unpublished data). Long-term trends in logbook CPUE are presented, as a fishery-based index of trends in biomass, for comparison with other fishery-based and survey indices.

The number of trap hauls from logbooks was calculated for each Division on a weekly basis to compare the seasonality of the distribution of fishing effort among years, and CPUE was calculated on a weekly basis to assess fishery performance throughout the season in inshore areas each year. Similarly, weekly CPUEs were compared against the weekly cumulative catch to assess the performance of the fishery against the level of removals in inshore areas each year. Logbook CPUEs were also mapped for 10' x 10' (nautical minutes) and 2.5' x 2.5' cells in the offshore and inshore areas respectively, encompassing the entire fishery distribution each year, and used to qualitatively assess area-specific fishery performance within each division.

The spatial extent of annual fishing effort for inshore and offshore areas of each 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.

Catch per Unit Effort indices in offshore areas were correlated against annual bottom temperature and habitat indices in each division at lags of best-fit, as were the biomass indices from the multi-species trawl surveys, to assess the effect of thermal regime during early life history on future fishery success.

OBSERVER CATCH-EFFORT AND AT-SEA SAMPLING DATA

Set and catch data were available from the Observer Program for the same time series as those from the multi-species surveys (1995-2012), but at-sea sampling data have only been collected since 1999. Levels of sampling are generally highest in offshore Div. 3KLNO due to high observer coverage in those areas (Fig. 4). Sampling has been consistently low in inshore CMAs and virtually absent throughout Divisions 2H and 4R. The observer set-and-catch database included details about number and location of traps, landed catch (kg), and discarded catch (kg) for each set observed. An observer-based CPUE index (kg. landed/trap haul) was calculated from observer data for comparison with inshore and offshore logbook CPUE. This catch rate index was based on set and catch estimates from 1995-98, when no detailed sampling was conducted, whereas it has since been based on detailed sampling of individual crabs.

For offshore areas, where data permitted, 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 preceding trawl survey biomass index of pre-recruits. 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 measured under-sized and soft-shelled pre-recruits (and undersized adult males) discarded in the fishery, in year t, calculated from observer sampling data. Pre-recruit biomass index (PBI) is an index of the biomass of pre-recruits (and under-sized adult males) ($t \times 1000$) from the preceding survey; i.e. the fall survey of the previous year for Div. 2HJ3KLNO or the spring survey of the same year for Subdiv. 3Ps. S is a scaling factor to account for incomplete and annually variable levels of observer coverage, defined as:

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

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 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 from biological sampling by observers was also used to quantify the catch components, discarded or retained, in the fishery. Entire trap catches of males were sampled for CW (mm) and shell condition. Shell condition categories differed slightly from those used 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). Also, seasonal trends in the percentage of soft-shelled crabs were described. Discarding of recently-molted (especially 'soft') immediate pre-recruits is believed to impose a high mortality on those individuals. A soft-shell protocol was implemented in 2004 to close specific small fishing areas when the percentage of soft-shell crab reached 20%. This was reduced to 15% for offshore Div. 3LNO in 2009 and 2010.

VESSEL MONITORING SYSTEM AND DOCKSIDE MONITORING PROGRAM DATA

Data on hourly offshore vessel positions from VMS, and landed catch from DMP, were obtained from the Fisheries Management Branch and the Policy and Economics Branch, Statistics Division, DFO Newfoundland Region. 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 (2009). Fishing hours were screened based on location and speed from hourly positional signals. Signals occurring at 0.1 – 3.0 knot speeds were accepted as fishing signals.

Vessel monitoring system-based CPUE is used as an index of biomass and compared with commercial logbook and observer-based CPUE indices; VMS-based CPUE, like the other CPUE indices, is unstandardized in that it does not account for variation in fishing practices (eg. soak time and vessel drift) (Mullowney and Dawe 2009). Trends in VMS-based CPUE are used as the primary catch rate index only for offshore areas where all fleet sectors are required to use VMS (Div. 3KLNOP4R). Analogous to depletion indices developed from logbook data in inshore areas, VMS CPUE was calculated on a weekly basis to assess fishery performance throughout the season in offshore areas each year. Similarly, weekly CPUEs were compared against the level of cumulative catch to assess the performance of the fishery in relation to the level of removals in offshore areas each year.

INSHORE TRAP AND TRAWL SURVEYS

Data were available from inshore Div. 3K trap surveys that were carried out in White Bay and Notre Dame Bay during 1994-2012. There were no surveys in either bay in 2001, and no survey was conducted in Notre Dame Bay in 2009 or 2011. The survey has consistently occurred in September and occupies 5 of the inshore fall multi-species survey strata (Fig. 5) with a target of 8 sets per stratum. Each set includes 6 traps, with crabs sampled from two large-meshed (commercial, 135 mm) 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). Mortality was also inferred from levels of BCD observed in these surveys.

Data were also available from two inshore trap and trawl surveys (1979-2011) within Div. 3L (Bonavista and Conception Bays) and one within Subdiv. 3Ps (Fortune Bay, 2007-11) (Fig. 5). These surveys were conducted in different seasons; spring (Fortune Bay- 3Ps), summer (Bonavista Bay- 3L), and fall (Conception Bay -3L). The Fortune Bay survey covered three depth strata while the Bonavista and Conception Bay surveys covered only the deepest stratum in each bay where the commercial fishery was thought to concentrate. All surveys utilized traps of various mesh sizes for each set, including two small-meshed (27 mm) traps. For each survey series, catch rate indices and size distributions were produced as described above for the inshore Div. 3K trapping surveys, and prevalence of BCD was noted. The trawling portion of these surveys utilized a survey trawl with small rock-hopper footgear, that is believed to have a higher capture efficiency for snow crab than the Campelen 1800 trawl used in the offshore multi-species surveys. No survey was conducted in Fortune Bay in 2008, and the trawling portion of the survey in 2009 was omitted from analyses due to gear misconfiguration in that year.

POST-SEASON TRAP SURVEY

Data were examined from industry-DFO Collaborative Post-Season (CPS) trap surveys in Div. 2J3KLOPs4R (Fig. 6). These surveys, funded by the Fisheries Science Collaborative Program (FSCP), were examined for the first time in 2006. They were initiated following the 2003 fishery and conducted annually thereafter, beginning Sep. 1 each year. The surveys, conducted by snow crab harvesters accompanied by at-sea observers, focus on commercial (ie. deep) fishing grounds within individual CMAs, and as such are more spatially-limited than the multi-species trawl surveys. Survey stations are fixed and generally follow a grid pattern, with a maximum station spacing of 10' X 10' (Fig. 6). 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 one trap at each station. Sampling includes determination of carapace width, shell condition, leg loss, and presence of BCD. Small-meshed traps are included at selected stations to collect information on pre-recruits and females. Biological sampling of males from small-meshed traps includes determination of chela height. However, due to temporal and spatial inconsistencies in the distribution of small-mesh traps, indices are not available for all areas in all years. Furthermore small-meshed traps do not adequately sample pre-recruit crabs in some areas due to a survey design that focuses on sampling of exploitable crabs, with limited sampling of shallow-water small-crab habitat.

For analysis of catch rates (numbers per trap), a set of core stations was selected from the survey (Fig. 6) due to incomplete and spatially variable survey coverage each year. Biomass indices derived from this survey were based on a stratification scheme introduced into the assessment two years ago (Mullowney et al. 2012a) (Fig. 6). In previous years, the multi-species trawl survey stratification scheme was used to derive biomass estimates from the CPS trap survey (Dawe et al. 2011). However, it was abandoned due to poor and non-random spatial coverage of the stratification template by the CPS survey. The depth-based stratification scheme closely conforms to all stations occupied in inshore and offshore management areas of each division since 2004. The boundary of each stratum extended 5 nm outside the outermost stations of each survey grid. The set of strata used was common to all years for each zone. Exploitable and pre-recruit biomass indices were calculated from trap survey catch rates using STRAP in a fashion similar to its application to the multi-species survey data, modifying the program with respect to the area-depth stratification scheme and applying an effective area fished of 0.0053 km² (Dawe et al. 1993), analogous to the area swept by a single trawl survey tow, to extrapolate trap catch rates across the total survey area. Trends in the pre-recruit biomass index from this survey is biased in that CH is not determined. Although sub-legal-sized

terminally-molted adults will never recruit or contribute to the future exploitable biomass, they are included in the size-based pre-recruit biomass index from the trap survey. An examination of shell condition of 76-94 mm CW males from this survey was introduced into this assessment, toward inferring the proportion of pre-recruit-sized crabs that remain adolescent and will continue to molt. This assumes that old-shelled pre-recruit-sized crabs would have a higher likelihood of being terminally molted adults than would new-shelled crabs of the same size.

RESULTS AND DISCUSSION

DIVISION 2HJ3KLNOPS4R

The Fishery

The fishery began in Trinity Bay (Management area 6A, Fig. 2) 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 1980s, 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 of Div. 3K and 3L while new fisheries started in Div. 2J, Subdiv. 3Ps, and offshore Div. 3K. Since the late 1980s, the resource has increased in these areas. Commercial quota allocations for Div. 4R began in the early 1990s and in Div. 2H in 2008, although there were prior small-scale exploratory fisheries in these areas. No commercial quota was allocated in Div. 2H in 2012.

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 1990s. 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 and exploratory licences in the offshore were converted to full-time licences in 2008. There are now several fleet sectors and about 3100 licence holders in the fishery, with several rationalization initiatives gradually reducing the number of active licences in recent years. In the late 1980's, quota control was initiated in all management areas 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 more stringently ensure compliance with fishing area regulations.

The fishery was traditionally prosecuted during summer and fall but has become earlier in recent years and is now primarily prosecuted during spring and early summer. Late fishing seasons are believed to contribute to a high incidence of soft-shelled immediate pre-recruits in the catch. The fishery can be delayed in northern divisions (Div. 2HJ3K) due to ice conditions in some years. Such severe ice conditions can affect the spatial distribution of fishing effort and fishery performance. The fishery can also be delayed for other reasons such as price disputes which have become common in recent years.

Historically, most of the landings have been from Div. 3KLNO. Landings for Div. 2HJ3KLNOP4R (Table 1, Fig. 7) increased by 22% from 44,000 t in 2005 to 53,500 t in 2009, and since declined marginally to 50,500 t in 2012, with an increase in the South (Div. 3LNOPs) and a decline in the North (2HJ3K).

Effort, as indicated by estimated trap hauls, approximately tripled throughout the 1990s (Dawe et al. 2004) primarily due to vessels <35 feet with temporary seasonal permits entering into the fishery. The distribution pattern has since remained broad-based, with only slight annual changes in recent years (Fig. 8). A reduction of fishing along the slope edges occurred in Divs. 2HJ3KOPs after 2003. Effort expenditure increased greatly in offshore Div. 3K from 2008 to

2009 and remained relatively high since (Fig. 8). Effort within the inshore areas of Div. 4R had become increasingly contracted and highly aggregated throughout the 2000s, but the fishery has re-emerged in recent years. Another notable change in recent years has been an increase in effort in the west-central portion of the Grand Bank (in CMA 8B) since 2008.

Biomass

The fall distribution of exploitable males (legal-sized adults) (Fig. 9) as well as pre-recruits (>75 mm adolescents) (Fig. 10) throughout NAFO Div. 2HJ3KLNO in 2012 was generally similar to the distribution pattern observed when biomass levels were higher during the late 1990s, as previously described by Dawe and Colbourne 2002, with some notable exceptions. Large males have consistently been virtually absent over a broad area of the shallow (<100 m) southern Grand Bank throughout the time series. The abundance of largest males (Fig. 9) has decreased in the northernmost areas (Div. 2J3K) since the 2007-2009 period, while increases or consistent levels have occurred in the southernmost areas (Div. 3LNO). Survey catch rates of pre-recruit males (Fig. 10) were generally lower throughout the survey area in 2011-2012 compared to 2008-10. Densest aggregations of smallest males (<60mm CW, Fig. 11) occurred in the north (Div. 2J3K) in 2007-08, but a notable shift to southern divisions (3LNO) has since occurred, with high catch rates of small males largely restricted to Div. 3LNO in 2012. There has also been a marked decrease in abundance of mature females across the entire survey area in the past three years (Fig. 12).

The multi-species trawl surveys indicate that the exploitable biomass declined from 2008 to 2011 and was unchanged in 2012 (Fig. 13). The fall post-season surveys contribute most greatly to the overall picture, indicating that in Div. 2J3KLNO the exploitable biomass was highest during 1996-98 with a secondary peak occurring in the late 2000s.

Production

Recruitment

Recruitment has recently declined and is expected to decline further in the short term (2-3 years). The increased survey biomass indices of pre-recruits (Fig. 13) from 2005-09 was primarily due to increases in the south (Div. 3LNOPs). Long-term recruitment prospects are unfavourable due to a recent warm oceanographic regime. The snow crab thermal habitat index (Fig. 14), reflecting the areal distribution of cold water beneficial for early survival and subsequent recruitment, decreased in all divisions since the late 1990s, despite a high level of annual variability. This was especially clear in the northern divisions (2J3K) where the index was near zero in 2011. While a general decrease in area of cold water has occurred in 3LNO, in both spring and fall, the degree of warming in the south appears to have been generally lower than in the north, especially in southern-most Subdiv. 3Ps where recent decreases in the coverage of cold water have been least severe (Fig. 14).

Low bottom temperatures promote terminal molt at small sizes in snow crab, resulting in relatively low recruitment and yield-per-recruit from a given year class (Dawe et al. 2012a). However, recruitment is more strongly affected by the positive effects of a cold regime on year class production (Marcello et al. 2012) 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 and 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-1980s to about 1995. These were years of high crab productivity that led to high commercial biomass and catch rates during the late 1990s. A warm oceanographic regime

has persisted over the past decade (Colbourne et al. 2013) implying poor long-term recruitment prospects.

The fall surveys suggest that there had been a decline in abundance indices of smallest males (<40 mm CW) since the early 2000s that would likely result in reduced biomass in the long term (Figs. 15-16). These size frequencies also show the decrease in abundance of pre-recruit (>75 mm CW adolescent) and exploitable (>94 mm CW adult) males that has occurred in recent years. 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 do not molt. These variables currently cannot be predicted and so are not accounted for.

Reproduction

The abundance of mature females (Fig. 17) captured during the fall trawl survey was highest in 1995 and declined precipitously to 1998. It varied without trend for most of the 2000s but increased sharply in 2008. It has since declined to its lowest level in 2012. The percentage of mature females carrying full clutches of viable eggs has remained high (i.e. exceeding 80%) in most years, but exhibited a declining trend during the past three years. The effects of reduced abundance of mature females and lower percentages carrying full clutches of viable eggs in recent years on production and subsequent recruitment are not presently known but may be a cause for concern.

Mortality

Bitter Crab Disease has been observed in snow crab, based on macroscopic observations, at generally low levels throughout 1996-2012. 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) and appears related to circulation features along the NL shelf (Dawe et al. 2010b) and the density of small adolescent crabs (Mullowney et al. 2011). This density-dependent disease is thought to moderate the strength of recruitment pulses occurring in the population.

There had been a broadly-distributed incidence of bitter crab disease during 1996-2006, but the distribution became limited to localized aggregations at low prevalence, primarily in Div. 3KL, in 2007 (Fig. 18). In 2008, BCD prevalence increased in offshore portions of Div. 2J3K, but it was virtually absent across most of the survey area in 2009. In 2010, there appeared to be a substantial increase in the distribution and prevalence of BCD in offshore Div. 3K. However, this increase has been attributed to Technician error and deemed anomalous. Bitter crab disease has been virtually absent across most of the survey area in the past two years. The low incidence of BCD in recent years is positive in that it reflects a reduced level of mortality in the population, but it is negative in that it reflects a reduced overall abundance of small crabs along the NL shelf.

This disease, which is fatal to crabs, primarily occurs in new-shelled crab of both sexes and appears to be acquired during molting (Dawe 2002). It is unknown how well apparent disease prevalence in trawl-caught samples represents true prevalence in the population, as diagnosis

has been based on recognition of external characteristics in chronic cases. However, it seems likely that our observations underestimate true prevalence.

DIVISION 2HJ

The Fishery

The Division 2HJ fishery occurs in offshore regions of central and southern Labrador in CMAs 1 and 2 (Fig. 19). The bathymetry is characterized by a series of shallow water offshore banks separated by deep channels. The fishery in Div. 2H is small relative to Div. 2J. There had been exploratory fisheries in Div. 2H since the mid-1990s and a commercial TAC was first established in 2008. The history of fishing in 2J is longer, extending back into the early 1980s. Landings in Div. 2HJ (Table 2, Fig. 20) decreased by 37% since 2008 to 1,600 t. Meanwhile, effort increased by 55% to 2011 before decreasing by 23% in 2012. The TAC has not been taken in the past 2 years. Commercial catch rate (CPUE) from logbooks has oscillated over the time series (Table 2, Fig. 21), initially decreasing from 1991-95, and increasing to a peak in 1998. It declined steadily by 76% from 1998 to a record low level in 2004. It increased once again to its most recent peak in 2008, then declined steadily by half to 2011 and was unchanged in 2012.

All three CPUE indices generally trended together with the exception of an anomalous increase in VMS CPUE in 2011 (Fig. 21). In Div. 2HJ, not all vessels are required to use VMS, thus trends in VMS CPUE are susceptible to fleet-specific phenomena. The increase in VMS CPUE in 2011 was related to heavy ice conditions in that year, that resulted in earlier fishing by large vessels (equipped with VMS) than by smaller vessels. The large-vessel fleet was able to capitalize on high early-season catch rates relative to the average CPUE across all fleets throughout the season, as reflected in the logbook and observer CPUE series'. The logbook and observer indices agreed that CPUE was unchanged in 2012.

The 2012 fishery was concentrated in Hawke and Cartwright channels (Fig. 22) as has been the norm in recent years. Annual effort distribution in Div. 2H has been variable, likely reflecting the low biomass of crab. In 2012, there was virtually no effort above the Div. 2H line, due in part to a management change that allowed a fleet previously restricted to Div. 2H to access the northern portion of Div. 2J. In Div. 2J, there was an emergence of some effort in the north outside of normal fishing areas to the west of Harrison Bank in 2011, with some effort maintained in this area in 2012.

The 2010-12 fisheries began in early May and virtually all effort was expended by about mid-August (i.e. week 14) each year (Fig. 23).

Biomass

Commercial CPUE has oscillated over the time series and is currently low, as indicated by all three indices (Fig. 21). Decreases in fishery performance have occurred throughout Div. 2HJ in the past few years (Fig. 24), with the Cartwright Channel area in the northern portion of Div. 2J performing especially poorly in 2011-12.

The spatial coverage of the fishery has been inversely related to commercial CPUE (Fig. 25). The percentage of available 5' x 5' cells occupied by the fishery declined sharply from its highest level of 19% in 2004 to its lowest level of 8% in 2006. It gradually increased to a secondary high of 14% in 2011 but decreased abruptly in 2012 when the fishery became contracted into the Cartwright and Hawke Channels. The general inverse relationship between spatial coverage of the fishery and commercial CPUE reflects harvester searching behaviour, with the necessity to search for new or alternate fishing grounds when catch rates are low or in decline. Conversely, when catch rates are high, there is little need to search for alternate fishing grounds. However, in Div. 2HJ the annual distribution of ice coverage may also influence the

spatial distribution of fishing, such as in 2009, when the spatial index increased sharply during a heavy ice year. The phenomenon of a low CPUE coupled with a low areal extent of fishing effort in 2012 is unique and is likely influenced by poor catch rates experienced in 2011 outside of the primary fishing grounds within the Cartwright and Hawke Channels (Fig. 24), together with the high operating cost associated with searching. This implies an increasing reliance of this fishery on these two primary areas, which themselves have yielded poor catch rates in recent years.

Weekly CPUE trends are normally highest during the early portion of the season and tend to decline during the first 4-5 weeks of fishing each year (Fig. 26). Catch rates normally remain low for the duration of the season thereafter although in some years they may increase slightly during the latter portions of the season under minimal effort. In 2011, weekly CPUE was at its lowest observed level in recent years for most of the season. The 2012 fishery performed slightly better in the early weeks but performed at a similarly poor level later in the season. In relation to cumulative removals, the 2012 fishery performed very poorly, with catch rates at recent lows for the duration of the season despite a greatly reduced level of removals (Fig. 26).

Size distributions from at-sea sampling by observers (Fig. 27) suggest the entry of a recruitment pulse into the exploitable biomass during 2007-09, as indicated initially by an increase in the abundance index of smallest exploitable crabs (about 95-101 mm CW) in 2007, an increase in the abundance index of legal-sized crabs to 2008, and a high proportion of new-shelled crabs in the catch, to 2009. It appears there was little recruitment into the exploitable population during 2010 and 2011, as catch rates of all sizes were reduced and few new-shelled crabs were seen in the fishery. In 2012, catch rates of all sizes of crabs ranging from 89-110 mm CW increased and the catch was dominated by new- and soft-shelled crabs. This could be indicative of another recruitment pulse entering into the fishery, a depleted residual biomass, or both. It is believed that the catchability of soft-shelled crabs increases when the ratio of soft to older-shelled crabs is high, with large older-shelled crabs out-competing their soft-shelled counterparts for baited traps. Despite the increased catch rates of small legal-sized (i.e. 95-110 mm CW) crabs in 2012, the overall observed catch rate in the fishery was unchanged from 2011, based on at-sea sampling data (Fig. 28). This infers a reduced biomass of largest crabs in 2012. The approximately 2 kg/trap of soft-shelled crabs captured in the 2012 fishery is the highest observed catch rate since 2004 (Fig. 28) and would imply an increased level of pre-recruit mortality imposed by the fishery.

The exploitable biomass has decreased in recent years. The post-season trawl survey exploitable biomass index declined steadily from 2006 to 2011 and was unchanged in 2012 (Table 3, Fig. 29). It remains low relative to levels observed in the late-1990s and mid-2000s. The trap survey index of exploitable biomass covered both the Cartwright and Hawke Channel areas during 2007 and 2010-12. The exploitable biomass index from that survey changed little during 2010-12 and was at a much lower level than in 2007. The capture of exploitable crabs by the trawl survey has become increasingly contracted into the Cartwright and Hawke Channels in recent years (Fig. 30) with virtually no exploitable crabs captured in Div. 2H or along the slope of either division in the past two years.

The increase in the fall survey exploitable biomass index from 2002-06 (Fig. 29) was small relative to the increase in CPUE indices (Fig. 21). This likely reflects the positive effects of recent management changes in the fishery as described earlier.

Production

Recruitment

Recruitment declined from 2006 to 2011, changed little in 2012, and is expected to remain low in the short term (2-3 years). The post-season trawl survey pre-recruit index decreased sharply

in 2005 and has since fluctuated without trend (Fig. 31). The post-season trap survey index has changed little during the past three years. Similar to the pattern observed for legal-sized crabs, the capture of pre-recruit males in the fall trawl survey has been almost exclusive to the Cartwright and Hawke Channels (Fig. 32).

Males enter the legal-size group as soft-shelled crabs, after the spring molt, and 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 1997-98 whereas that of intermediate-shelled males peaked in 1998-99 (Fig. 33). The biomass index of new-hard-shelled males dropped sharply in 1999, whereas that of intermediate-shelled crabs declined steadily during 2000-02. The biomass of new-hard-shelled crabs increased steadily from 2002-06 while the biomass of older-shelled crabs has remained low. This suggests that the fishery has been highly dependent upon immediate recruitment, which gradually declined from 2006-11. Shell condition-specific indices of legal-sized males from the CPS trap survey (Fig. 34) have shown no change in catch rate of either shell component during the past three years.

The size compositions from fall multi-species surveys (Figs. 35-36) are examined with the abundance index (ordinate) truncated for smallest males (<50 mm CW), in order to focus on trends in abundance for larger males. A clear picture of a recruitment pulse entering into legal-size from 2004-08, and since dissipating, is evident in Div. 2H (Fig. 35). There were few crabs of any size captured in the Div. 2H 2011 or 2012 surveys. In Div. 2J, the data indicate that most of the relatively abundant sub-legal-sized adolescent males evident in 2004 achieved legal size in 2005-07, with the abundance of most sizes of legal-sized crabs having since declined (Fig. 36). The size distributions suggest that the abundance of smallest males (<50 mm CW) has been low in most recent years, with the exception of higher catches during 2007-09. However, there has been no clear evidence of modal progression over the time series in trawl survey data. The size compositions from large-mesh traps in the post-season trap survey (Fig. 37) show minor changes in composition and catch rate for most sizes of crabs during the past three years.

The catch rates of total discards in Div. 2J decreased substantially between 2004 and 2006, varied without trend until 2010, and increased in the past two years (Fig. 38). The recent increasing trend predominately reflects an increase in the catch rate of soft-shelled legal-sized crabs. At 2 kg/trap in 2012, soft-shell crab comprised more than half the total discards. The catch rates of under-sized crabs have been lower in the past three years than during a high period from 2007-09. High catch rates of soft-shelled crabs in the fishery from 2002-04 did not agree with low catch rates of new-shelled crabs in the post-season trawl survey (Fig. 33), implying high handling mortality in those years. Similarly, a spike in catch rates of soft-shelled crabs in the 2012 fishery does not correspond to an increased biomass of legal-sized new-shelled crabs in the post-season trawl survey, inferring once again a high handling mortality in the fishery this year.

An examination of shell condition in 76-94 mm CW crabs from the fishery (Fig. 39) and post-season trap survey (Fig. 40) indicates that a higher proportion of sub-legal-sized crabs were old-shelled during the past three years than in the previous three years. Assuming that most of these old-shelled crabs were terminally-molted adults, this infers reduced recruitment potential into the exploitable biomass and fishery in the short-term. Long-term recruitment prospects are unfavourable due to a recent warm oceanographic regime. The ocean climate indices have varied considerably over the past 8 years (Figs. 41-42), introducing uncertainty beyond the short term. However, the overall trend is warming, with record warm conditions in 2010 and 2011. A 6 year lag of both shallow-water bottom temperature and the thermal habitat index produces relatively tight relationships with both CPUE and exploitable biomass. The presence of some relatively cold conditions in 2008 and 2009 could imply some possible

improvement in recruitment in the near future but there is no supporting evidence of an imminent recruitment pulse in the trawl size frequency distributions (Fig. 36).

Reproduction

The abundance of mature females captured in the trawl survey has been relatively low during the past three years (Fig. 43). Mature females generally tend to be captured in shallower water than pre-recruit and legal-sized males as can be seen in 2008 and 2009 when high mature female catch rates occurred on top of the Hamilton Bank and in shallow waters off the headlands of southern Labrador (Fig. 44). The low abundance of mature females in the survey since then reflects a reduced abundance throughout the Division. The percentage of mature females carrying full clutches of viable eggs (Fig. 43) has varied over the time series, but consistently remained above 75%, including in the five most recent years. It is unknown to what extent changes in abundance of mature females may affect subsequent abundance of settling megalopae or (ultimately) fishery recruitment.

Mortality

Exploitation

The exploitation rate index declined from 2003-07 before increasing steadily to its highest level since 2004 (Fig. 45). Maintaining the current level of fishery removals would likely result in little change in the exploitation rate in 2013 but would likely result in high mortality on soft-shelled immediate pre-recruits. It would be precautionary to reduce the exploitation rate so as to promote recovery of the exploitable biomass.

Indirect Fishing Mortality

The pre-recruit fishing mortality rate index has been at its highest level since 2004 during each of the past two years. The percentage of the catch handled and released in the fishery increased from about 10% in 2008 to about 35% in 2012 implying a potential increase in pre-recruit mortality.

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 and dropping or throwing crab induces limb loss and also leads to increased mortality levels associated with catching and discarding crabs. Recently-molted (soft-shelled) snow crab are subject to more damage and mortality than hard-shelled crab (Miller 1977, Dufour et al. 1997). The increase in the level of soft-shelled discards in the Div. 2HJ fishery since 2008 (Fig. 38) implies increased wastage of immediate pre-recruit crabs. The catch rate of soft-shelled crabs in 2012 was at its highest value since 2005 and appears predominately due to elevated late-season soft-shell capture (Fig. 46).

Prevalence of soft-shelled legal-sized males is a function of both fishery timing and exploitable biomass level. Mortality on soft-shelled males can be minimized by fishing before recently-molted crabs are capable of climbing into traps and further reduced by maintaining a relatively high exploitable biomass level. The high soft-shell prevalence in the late stages of the fishery in recent years highlights the risk associated with continuing to fish when catch rates of hard-shelled crabs are low. The soft-shell protocol was introduced in 2005 to protect immediate pre-recruits from handling mortality by closing localized areas (70 sq. na mi. grids) for the remainder of the season when a threshold level of 20% of the legal-sized catch is reached.

However, it has become evident that this protocol, as implemented, is inappropriate and ineffectual in controlling handling mortality. This is largely due to very low observer coverage, together with the decision to treat unobserved grids as if they had no problem. In addition, failure to draw inferences from samples smaller than the minimum required has frequently resulted in failure to invoke the protocol even when it is clear that the level of soft-shelled crabs has exceeded the threshold. These shortcomings undermine the intent of the protocol. Also, when soft-shelled crab is widespread, grid closures can result in concentration of fishing effort in other areas with high but unobserved prevalence. This is particularly problematic in Div. 2HJ where the fishery has become concentrated in two localized areas, the Hawke and Cartwright Channels, such that there is limited ability of fishing fleets to avoid areas of high soft-shelled crab prevalence. Measures should be taken to ensure representative observer coverage and analysis so as to better quantify prevalence of soft-shelled crabs in the fishery.

An area of Hawke Channel has been closed to all fisheries except snow crab from 2003 to 2012 ("Hawke Box"-Fig. 19). Catch per Unit Effort has generally trended similarly inside and outside the closed area since its inception (Fig. 47), although they diverged in 2012, increasing inside while decreasing outside the Box. However, the prolonged tight agreement of CPUE inside versus outside the closure implies that other fisheries that do not target snow crab do not represent a major source of snow crab mortality. A recent study on the effectiveness of this closed area concluded that the Hawke Box has failed to protect pre-recruit crabs largely due to an intensification of the crab fishery inside of it in the years surrounding closure. There were high discard rates of soft-shell crab, at 50-75% of the catch, during 2002-04 leading to a long-term reduction in snow crab productivity in the Hawke Channel (Mullowney et al. 2012b).

Natural Mortality (BCD)

BCD occurs almost exclusively in recently-molted crabs (Dawe 2002, Mullowney et al. 2011). Overall, prevalence has generally been low in this area and most apparent in small new-shelled crabs of 40-59 mm CW with about 2-3% occurrence in most years, excepting 1999 and 2008, when 18% and 16% respectively of new-shelled adolescents of that size group were visibly infected. Bitter crab disease has been absent in Div. 2J since 2009, consistent with a low density of small crabs and poor long-term recruitment prospects, which are being driven by the recent warm oceanographic regime.

DIVISION 3K OFFSHORE

The Fishery

The Division 3K offshore fishery occurs off the northeast coast of Newfoundland, predominately concentrating between near-shore shallow regions and the Funk Island Bank (Fig. 49). It incorporates CMAs 3BC and 4 and a portion of 3A. Landings first peaked in 1999 at 17,900 t (Table 4, Fig. 50). They decreased to about 13,000 t in 2000-04, due to a reduction in the TAC and dropped to about 6,000 t 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. Most recently, landings increased from 2005 to peak at 12,600 t in 2009, but decreased by 52% to 6,000 t in 2012. The TAC has not been taken in the past 3 years. Effort decreased sharply in 2005 and changed little until it increased by 71% to a peak in 2009. It has since declined by 31% (Table 4, Fig. 50). Commercial CPUE (Table 4, Fig. 51) indicates substantial deterioration of fishery performance in recent years. Following a peak in 2007 (VMS) or 2008 (logbook, observer), all three indices agree that CPUE declined by half from 2008 to 2011 and changed little in 2012.

There have been notable changes in the distribution of the Div. 3K offshore fishery in recent years (Fig. 52) with effort having intensified, especially in 2009-10. The most distinctive

increases have occurred in the northwest portion of the Division, in and around the St. Anthony Basin, and throughout the Funk Island Deep in the central portion of the Division. Along with a resource issue, as indicated by an inability to take the TAC in recent years, the recent broader-scale distribution of effort could be partly due to early season ice coverage (especially in 2009) or application of the soft-shelled protocol which alters the spatial distribution of effort and may adversely affect fishery performance. These factors may have also contributed to an extension to depths greater than those usually fished, such as the mid portions of the Funk Island Deep, during the past three seasons.

The temporal distribution of the fishing effort has changed little since 2007, with the exception of an early fishery in 2011 (Fig. 53). In most years the fishery starts to expend notable levels of effort around early May (i.e. week 4) and most of the effort is expended by the end of July (i.e. week 13).

Biomass

The exploitable biomass remains low. The deterioration of fishery performance over the past two years has occurred throughout Division 3K offshore (Fig. 54). Only a few localized areas have yielded catch rates exceeding about 10 kg/trap since 2009. The spatial coverage of the fishery has been inversely related to commercial CPUE since 1995 (Fig. 55). The percentage of available 5' x 5' cells occupied by the fishery increased abruptly in 2009, exceeding 40% for the first time since 2004, and has since remained high, while CPUE has declined.

VMS-based CPUE was lower throughout the season in 2011 and 2012 than during the previous three years (Fig. 56). Initial CPUE in 2012 was very low, but by the first part of May (i.e. week 4) weekly catch rates began to reflect those of 2011, a pattern which persisted for the duration of the season. When measured against cumulative removals, the fishery performed more poorly in 2012 than in 2010 and 2011, with an obvious sign of depletion beginning to occur at about 2,500 t of removals as opposed to at 4,000-4,500 t in 2010 and 2011. Late season CPUE, at more than 4000 t of removals, was clearly lower than in the previous 4 years.

Size distributions from at-sea sampling by observers (Fig. 57) show that modal CW has not changed since 2005. Generally, successive decreases across the entire size range of legal-sized crabs have occurred since 2008. This decline has occurred in both the new-shelled and old-shelled components of the legal-sized population. The observed catch rates of legal-sized old-shelled crabs began to decline in 2008 while the decline in new-shelled crabs began in 2009 (Fig. 58). Both components reached recent lows in the past two years.

The post-season trawl survey exploitable biomass index decreased from its highest level in the late 1990s to its lowest in 2003, before increasing to 2007 (Table 5, Fig. 59). The post-season trap survey exploitable biomass index increased in 2006. Both indices remained high to 2008. The exploitable biomass, as indicated by both survey indices, declined by more than half from 2008 to 2011 and was unchanged in 2012. The pattern of distribution of exploitable crabs from the trawl survey has been relatively consistent since 2007, generally associated with deep areas near the periphery of offshore banks and plateaus (Fig. 60). It is clear that the decrease in exploitable biomass has occurred throughout the offshore since 2008.

Production

Recruitment

Recruitment declined after 2008 and prospects remain poor in the short term (2-3 years). Post-season pre-recruit biomass indices from both trap and trawl surveys have decreased by about 55% since 2008 (Table 5, Fig. 61). The recent decrease in recruitment was likely exacerbated by a high handling mortality on soft-shelled immediate pre-recruits in the fishery.

Trawl survey catches indicate that pre-recruit crabs, like exploitable crabs, have declined in abundance throughout the offshore (Fig. 62).

The recent decrease in recruitment is reflected in the large reduction in the trawl survey biomass index of new-shelled legal-sized crabs (Fig. 63), with an especially sharp decrease in 2009. This index of recently recruited crabs was at a historical low in 2011. Similarly, catch rates of new-shelled legal-sized crabs in the CPS trap survey have declined in recent years, reaching a historical low in 2011 (Fig. 64). Both surveys were consistent in suggesting a slight increase in recruitment in 2012 and little change in the biomass of older-shelled crabs in the past four years.

Size frequency distributions from the post-season trawl survey (Fig. 65) show a clear decrease across the entire size range of crabs since 2008, with little change in the past three years. Similarly, size frequencies from the CPS trap survey (Fig. 66) show a clear decrease across the entire size range of crabs since 2008, with only minor changes in the past three years. Size frequencies from small mesh traps in the CPS survey (Fig. 67) have shown no clear patterns in catch rates of adolescent crabs since 2006. The lack of coherence in annual catch rate distribution and patterns in the small-mesh traps likely reflects the limited spatial distribution of these traps and deployment in this survey at depths beyond those normally associated with small crab habitat.

The observed catch rate of under-sized crabs in the fishery has changed little since at-sea sampling began in 1999 (Fig. 68), remaining about 1 kg/trap each year. Soft-shell crab discards have shown more variability. Lowest soft-shelled incidence during 2006-08 was associated with the high exploitable biomass in those years, and the 2009 peak in soft-shell discards was associated with the abrupt decline in new-shelled legal-sized crabs in the fall trawl survey (Fig. 65). This implies a high handling mortality in the fishery in that year. Following lower catch rates of soft-shelled crabs in 2010-11, catch rates once again increased in 2012. An examination of shell condition in 76-94 mm CW crabs from the fishery (Fig. 69) and post-season trap survey (Fig. 70) indicates that an unusually high proportion of sub-legal-sized crabs were old-shelled in 2011, which would infer a lower level of potential recruitment into legal-size in 2012. However, both indices returned to recent norms in 2012.

Long-term recruitment prospects are unfavourable due to a recent warm oceanographic regime. The ocean climate indices have varied considerably over the past 8 years, introducing uncertainty beyond the short term (Figs. 71-72). However, the overall trend is warming, with record warm conditions in 2011. Fits of both lagged CPUE and exploitable biomass against ocean climate indices of bottom temperature and habitat index are poorer in this Division than anywhere else, reducing certainty in making predictions for the future. However, the normal pattern of a negative relationship between CPUE and/or biomass and bottom temperature is evident as is the pattern of a positive relationship of CPUE and/or biomass with the habitat index. The relationships in this area are likely influenced by a relatively high level of soft-shelled crab mortality in the fishery in most years.

Reproduction

The abundance of mature females captured by the multi-species trawl survey has been low in the past three years (Fig. 73) while the percentage of mature females carrying full clutches of viable eggs has remained high at 90-100%. The recent decrease in abundance of mature females in the trawl survey has occurred throughout the offshore (Fig. 74). The implications of annual changes in abundance of mature females on production of early-life stages and subsequent recruitment are unknown.

Mortality

Exploitation

The trawl survey-based exploitation rate index increased sharply from 2008 to 2010 and changed little in 2011 before decreasing in 2012 (Fig. 75). Maintaining the current level of fishery removals would likely result in little change in the exploitation rate but would likely result in high mortality on soft-shelled immediate pre-recruits in 2013.

Indirect Fishing Mortality

The pre-recruit fishing mortality rate index increased from 2007 to 2011 but decreased in 2012 (Fig. 75). The percentage of the catch handled and released in the fishery increased from about 7% in 2008 to about 20% in 2012, implying a potential increase in wastage of pre-recruits. The recent increases in percent discarded likely reflect the generally high levels of soft-shelled crabs encountered for long periods of the fishing season in recent years (Fig. 76). There is a general trend for soft shelled crab occurrences to increase with time throughout the season, and during the past three years levels have regularly exceeded the twenty percent threshold for grid closures by about weeks 10-13 (i.e. mid to late June). The massive expanse of fishing grounds in Div. 3K and associated high number of grids coupled with low observer coverage levels makes application of the soft-shell protocol especially ineffectual in this area and likely results in a prolonged period of fishing on high levels of soft-shelled crab. The continuation of the fishery into late summer during 2009-11 resulted in fisheries that expended effort for up to eight weeks on high levels of soft-shelled crab.

A portion of the Funk Island Deep in the south of Div. 3K offshore (Fig. 49) was closed to gillnet fisheries in 2002 and has been closed to all fisheries except snow crab during 2005-12. The fishery had performed better inside than outside this area prior to its closure. Rather than increase the CPUE inside relative to outside this area, the closure had an opposite effect with little difference in fishery performance inside versus outside since 2005 (Fig. 77). This was likely due to the large increase in snow crab fishing effort inside the exclusion area since its implementation (Fig. 52). High levels of exploitation by the crab fishery are likely preventing this area from being effective at protecting pre-recruit crabs. This situation is similar to the outcome of the Hawke Box closure area in Div. 2J (Mullowney et al. 2012b), and re-iterates that levels of pre-recruit mortality imposed by other fisheries are of little concern relative to the levels imposed by the crab fishery itself.

Natural Mortality (BCD)

Prevalence of BCD, from multi-species trawl survey samples (Fig. 78), has been higher in this division than anywhere else. Maximum levels during 1996-1998, and 2008, were in the order of 8% in 40-75 mm CW new-shelled males. Bitter crab disease has been virtually absent since 2008, with the high 2010 values deemed anomalous due to Technician error. Prevalence of BCD has been shown to be directly related to host density (Mullowney et al. 2011). Annual trends in BCD prevalence (across all sizes) were similar to those in the survey biomass indices, especially for pre-recruits (Fig. 61), featuring highest values in 1996-98, a sharp drop to minimum levels in 1999, generally lower levels during 2000-07, an increase in 2008, and a lower level since. The lower prevalence levels in recent years are consistent with a decline in the density of small crabs and reduced long-term recruitment prospects associated with the warming oceanographic regime (Fig. 72).

There is some concern by industry that increased predation by cod (*Gadus morhua*) has contributed to the recent declines in snow crab biomass in Div. 3K. Although snow crab have been shown to contribute only minimally to the diet of cod in offshore portions of the northeast Newfoundland shelf (Dawe et al. 2012b), the importance of snow crab in the diet of cod showed

a moderate increase in 2012, which seemed to be driven by an increase in the incidence of large cod (>65 cm) eating snow crab in Div. 3K. Chabot et al. (2008) showed that cod gape size limited the ability of small cod to prey upon snow crab in the Gulf of St. Lawrence, with large crab (i.e. >65 mm CW) virtually immune to cod predation. With a very low abundance of large cod along the Northeast Newfoundland shelf since the cod stock collapsed in the early 1990s, it is not likely this was the main driver of the recent Snow Crab resource declines, but the issue could become of increasing importance if the abundance of large cod increases.

DIVISION 3K INSHORE

The Fishery

The Div. 3K inshore fishery occurs in CMAs 3B, 3C, and 3D in bays and adjacent to the northeast coast of Newfoundland (Fig. 79). Landings (Table 4, Fig. 80) have oscillated since 1995 with recent peaks in 2003 and 2009. They increased from 2,200 t in 2005 to 2,900 t in 2009, but decreased by 34% to 1,900 t in 2012. The TAC was not taken in the past 4 years in 2 of the 3 management areas (3C and 3D). Effort increased by 70% from 2008 to 2011 before decreasing by 19% in 2012 (Table 4, Fig. 80). Fishery CPUE has oscillated since 1990, most recently peaking in 2008 and is presently low (Fig. 81).

With limited room for spatial expansion in most CMAs, the fishing pattern has remained relatively consistent in recent years (Fig. 82). However, there have been some subtle changes including an expansion of effort in Green and Notre Dame Bays (CMAs 3C and 3D) in the past three years. The temporal distribution of the fishery has been similar for the past five years, with the exception of an early season in 2011 (Fig. 83). The fishery begins in mid to late April and runs to about mid-July in most years.

Biomass

Commercial CPUE (Table 4, Fig. 81) increased sharply from 2005 to a record high level in 2008, and then declined by more than half before increasing slightly in 2012. The sharp decline in CPUE from 2008-10 occurred throughout the Division, while recent improvements have been largely restricted to White Bay (CMA 3B). A high level of bias created by spatiotemporal inconsistency in the distribution of observer coverage among CMAs (Fig. 85) creates uncertainty in observer-based CPUE at the divisional level and does not allow for interpretation of observer CPUE in CMA 3B (Fig. 86). In recent years, CMA 3C (Green Bay) has received consistently high levels of observer coverage, whereas the other CMAs have been more annually variable (Fig. 85). Logbook and observer CPUE trends have been similar in CMA 3C (Green Bay) and 3D (Notre Dame Bay) (Fig. 86), reflective of the overall divisional trend of a substantial decrease from 2008-2011 and slight improvement in 2012 (Fig. 81). The CPUE trend in CMA 3B (White Bay) differs from the other two areas (Fig. 86), showing tremendous fluctuations in the past five years. The sharp decline in 2010 was associated with a high incidence of soft-shelled crab in the fishery, which resulted in early closure of the fishery with the quota not fully subscribed and improvement in fishery performance in the following year.

The spatial coverage of the fishery has been inversely related to commercial CPUE from 1996-2012 (Fig. 87). The area fished decreased from about 40-45% of available cells in 2004-05, to about 30% of cells occupied during 2006-08. It subsequently increased to a peak of 33% in 2011 before decreasing slightly once more in 2012. The slight decrease in spatial extent of the fishery in 2012 was opposed by a slight increase in CPUE.

Catch per Unit Effort indices show a pattern of depletion throughout the season in all recent years (Fig. 88). Trends in weekly commercial CPUE indicate that the fishery performed most poorly throughout the season in 2011, with 2012 faring better in all weeks. However, in relation

to cumulative catch, there has been little difference in the pattern of CPUE depletion, over the past three years. At about 2 kg/trap, catch rates have been very low at the end of the season in recent years.

The exploitable biomass, as indicated by the post-season trap survey index (Fig. 89), decreased from 2007 to 2009 and since changed little, but there is considerable variability among management areas. In a previous assessment (Mullowney et al. 2012a), the low 2009 index was deemed anomalous due to low capture efficiency of traps in some areas during the 2009 survey, particularly in White Bay (CMA 3B). However, upon re-examination of the data Mullowney et al. (2013) determined the 2009 White Bay survey was consistent with subsequent events that occurred in the fishery. For example, the sharp decline of CPUE in 2010 and subsequent recovery in 2011 in White Bay (CMA 3B, Fig. 86) reflects the exploitable biomass trend with a one year lag in the relationship (i.e. fall survey in 2009 followed by spring fishery in 2010). Accordingly, greater confidence is now afforded to the 2009 point in the exploitable biomass index. However, the 2011 survey point is now considered questionable due to unusually long soak times and poor trap performance in some CMAs, with White Bay again creating the most uncertainty.

Production

Recruitment

While uncertain, recruitment prospects appear to have changed little and there is considerable variability among management areas. The CPS pre-recruit biomass index of under-sized crabs (Fig. 90) has varied without trend throughout the time series. The CPS trap survey catch rates of new-shelled legal-sized males, constituting immediate recruitment for the fishery, has changed little since 2004, remaining at about 6 kg/trap (Fig. 91). Size frequency distributions from the CPS trap survey (Fig. 92) increased across the entire size range of crabs in 2010 but decreased in 2011, with little change in 2012. The percentage of new-shelled crabs in the 76-94 mm CW range has remained consistent at about 40-60% each year since 2004 (Fig. 93) inferring a relatively steady state composition of adolescents versus adults in under-sized crabs.

Mortality

Exploitation

The trap survey-based exploitation rate index changed little overall between 2011 and 2012 (Fig. 94). However, there was considerable variability among management areas, with the index decreasing slightly in two areas. The sharp increase in White Bay (CMA 3B) was a function of the anomalously low 2011 exploitable biomass index. Maintaining the current level of removals would likely have little effect on the exploitation rate in 2013. However, it would likely result in high mortality on soft-shelled immediate pre-recruits in some management areas in 2013.

Indirect Fishing Mortality

Spatiotemporal inconsistencies in the distribution of observer coverage do not allow for a reliable index of discards at the divisional level. Data are insufficient to estimate the pre-recruit fishing mortality rate index.

Natural Mortality (BCD)

BCD prevalence has been monitored by DFO trap surveys in White Bay and Notre Dame Bay (Figs. 95-98) since 1994. Bitter crab disease has consistently occurred at much higher prevalence levels in these inshore Div. 3K trap survey samples than in the offshore Div. 3K Campelen trawl survey samples (Fig. 78). 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. In White Bay,

prevalence has been periodic, with two distinct pulses of infection over the time series (Fig. 95). Peaks in prevalence have occurred in successively deeper strata at one to two year time lags. BCD prevalence patterns in White Bay are thought to reflect the relative abundance of small to mid-sized adolescents, and the time lag effect across strata likely reflects an ontogenetic movement of crabs to deeper waters over time (Mullowney et al. 2011). In 2009-12, BCD prevalence in all three White Bay strata was low, likely indicating that a recent pulse of adolescents has now progressed through the most susceptible size range. This is also apparent on a size-specific analysis for adolescents and adults, with all groups of crabs showing low BCD prevalence in all strata in 2009-12 (Fig. 96). In Notre Dame Bay, there have also been two pulses of infection (Fig. 97), but no clear difference in timing between strata as in White Bay. Prevalence originally peaked in 1996, and most recently in 2004-06. Interestingly, from 2006-08, prevalence was highest in large adolescents in shallow stratum 611, as opposed to smaller adolescents in deeper stratum 610 (Fig. 98). The whole of Notre Dame Bay was not surveyed in 2009 and deep stratum 610 was missed in 2011 due to inclement weather.

Spatial Variability: Trends by CMA

CMA 3B (White Bay)

Commercial CPUE has been sporadic in recent years, with a sharp decrease in 2010 followed by an equally sharp increase in 2011, and a subsequent decline in 2012 (Fig. 86). The sharp drop in 2010 was associated with a marked reduction in landings, with just over half the quota taken (Fig. 99), and an unusually high level of effort. The recent trend in fishery CPUE has tracked catch rates of new-shelled crabs in the CPS trap survey (Fig. 100), at a one year lag. The increase in new-shelled legal-sized crabs in the 2012 CPS survey is consistent with the DFO trap survey, which showed very large increases in catch rates of new-shelled legal-sized crabs in all three strata (Fig. 101). Both surveys indicate that the abundance of older-shelled legal-sized crabs (Fig. 100-101) is relatively low, indicating the fishery is largely dependent on immediate recruitment each year. The agreement of the two surveys in showing elevated catch rates of immediate recruitment prospects is positive for the fishery in the short term. Size frequency distributions from large-mesh traps in the CPS survey (Fig. 102) reflect the progression of modal size from about 90 mm CW in 2009 to 104-107 mm CW in 2012, indicative of a recruitment pulse that has entered into the exploitable biomass. Small-mesh trap size frequencies from the DFO survey (Fig. 103) appear anomalous in 2010 but reflect the recent increased catch rates of legal-sized crabs in 2011-12. However, they show a dissipation in the abundance of sub-legal-sized pre-recruits in all three strata since 2007, which suggests that most of the recent recruitment pulse is now contributing to the fishery and recruitment will likely decrease beyond the short-term. Longer-term recruitment prospects are unknown, but the decreased levels of BCD in small and intermediate-sized adolescents during the past four years (Fig. 96) could indicate a forthcoming decline, especially considering that the elevated BCD levels in 2005-08 likely signified the emergence of the recruitment pulse presently contributing to the improved exploitable biomass. Observer data indicate that the anomalous drop in CPUE in 2010 was associated with an above normal level of soft-shelled crabs in the catch during that year (Fig. 104). The early closure of the fishery in that year has been rewarded with a subsequent improvement in the fishery. It will be imperative to avoid soft-shell mortality if landings are to be maintained at or near the current level if recruitment into the exploitable biomass begins to decline in the near future.

CMA 3C (Green Bay)

There are discrepancies between in-season fishery and post-season survey trends in recent years. Fishery CPUE has oscillated since the late 1980s, and both logbook and observer data agree in showing a decline in catch rates from 2008-11, with little change in 2012 (Fig. 86). This

has been associated with declining landings since 2009 (Fig. 105) and an inability to take the gradually decreasing TAC in recent years. Observer sampling indicates the reduction in CPUE has been almost entirely due to a reduction in old-shelled legal-sized crabs (Fig. 106) of all sizes since 2008 (Fig. 107), with the last strong signal of new-shelled recruits occurring in 2007. However, in contrast, large-mesh traps in the CPS survey indicate that catch rates of new-shelled legal-sized crabs increased from 2008-11 (Fig. 108-109). The reasons for the discrepancies between in-season and post-season catch rate indices, of new-shelled crabs in particular, are unknown. Small-mesh trap size frequencies from the CPS survey (Fig. 110) indicate that the majority of a pulse of adolescents that had been approaching legal-size during 2010-11 terminally molted as under-sized adults in 2012. Consistently, observer sampling shows that most of the sub-legal-sized crabs captured in the fishery are old-shelled (Fig. 111), suggesting they are terminally-molted adults. The percentage of the catch discarded increased from 2007-10 and has been at 40% for the past two years (Fig. 112). This largely reflects the diminishing CPUE as discard rates of under-sized crabs have decreased and soft-shelled legal-sized crabs remained at about 1 kg/trap in recent years (Fig. 112). This has influenced the weekly percentages of soft-shell in the catch which have been persistently high in recent years, commonly approximating or exceeding the twenty percent closure threshold (Fig. 113). In 2011 and 2012, soft-shelled crab incidence remained at this level for most of the fishery, which implies a low exploitable biomass and relatively high level of fishery-induced mortality. Short-term recruitment prospects appear poor and long-term prospects are uncertain.

CMA 3D (Notre Dame Bay)

Fishery CPUE peaked at a record high level in 2008, decreased sharply to 2011, and changed little in 2012 (Fig. 86). The recent sharp decline in CPUE occurred despite substantial decreases in the TAC and landings (Fig. 114). Observer sampling indicates that the decline in CPUE has been attributable to reduced catch rates of both new- and old-shelled legal-sized crabs since 2008 (Fig. 115) across all sizes (Fig. 116). However, the CPS trap survey shows that catch rates of legal-sized crabs have been gradually increasing since 2009, primarily due to the new-shelled component (Fig. 117). Data from the DFO trap survey have been incomplete in recent years but indicate a large increase in catch rates of new-shelled legal-sized crabs from 2010 to 2012 (Fig. 118). Large-mesh trap size frequencies from the CPS survey showed slight increases in catch rates of 104-107 mm CW crabs in 2012 (Fig. 119) while small-mesh traps from the DFO survey showed increased catch rates of legal-sized and sub-legal-sized adolescents in 2012, particularly in deeper stratum 610 (Fig. 120). Together, these surveys are suggesting a slight increase in recent recruitment. However short-term prospects do not appear to be promising. Observer at-sea samples of pre-recruit-sized crabs have been dominated by old-shelled animals in most recent years (Fig. 121), and observer catch rates of under-sized and soft-shelled crabs have respectively changed little or decreased in the past three years (Fig. 122). Fisheries-induced mortality has been relatively high in the past two years, with incidence of soft-shelled crab regularly exceeding the 20% closure threshold, particularly during the latter parts of the season (Fig. 123). Long-term recruitment prospects remain uncertain but increases in BCD incidence in stratum 611 in the past two years, especially 2011, could signal some possible forthcoming improvements (Fig. 98).

DIVISION 3LNO OFFSHORE

The Fishery

The Div. 3LNO offshore fishery occurs on and surrounding the Grand Bank off Newfoundland's southeast coast (Fig. 124). It encompasses CMAs NS, MS, MSex, 3Lex, 3Lex3N, 3Lex3O, 8B, 3L200, 3N200, and 3O200. Landings, mostly in Div. 3L, decreased by 11% from 24,500 t in 2006 to 21,900 t in 2009 but since increased by 20% to 26,200 t in 2012 (Table 6, Fig. 125).

Effort increased by 80% from 2000 to 2008 and has since declined by 23% (Table 6, Fig. 125). Commercial CPUE (Table 6, Fig. 126) indicates that fishery performance has recently improved. VMS-based CPUE declined to its lowest level in 2008, but has since increased to above the average of the series.

Since 2007, most of the effort has been expended across the northern portion of the Grand Bank and along the Div. 3N slope edge (Fig. 127). There have been some minor changes in the distribution of fishing in recent years, such as a reduction in effort in the extreme northern portion of the area along the Div. 3KL line, the emergence of a pocket of effort in the central portion of the Grand Bank to the northeast of the Whale Deep, and an increase in effort inside of the Whale Deep area of Div. 3O. The 2011 and 2012 fisheries were early relative to the delayed fisheries of 2008 and 2010. During the past four years notable levels of fishing have begun in mid-April and most effort has been expended by mid-August (Fig. 128).

Biomass

In 2010, notable increases in CPUE occurred across most of the northern Grand Bank and along the Div. 3N slope while declines occurred in the Whale Deep (Fig. 129). Since then further increases have occurred in most of the area, but the Whale Deep and central portions of the Grand Bank have continued to perform poorly. The spatial coverage of the fishery has been inversely related to commercial CPUE since 1999 (Fig. 130). The percentage of available 5' x 5' cells occupied by the fishery increased from 2006-09 as CPUE declined, but since decreased while CPUE has increased.

VMS-based CPUE has shown a great deal of weekly variability during the past five years but was clearly higher in 2012 than in any of the previous four seasons (Fig. 131). There has been no suggestion of resource depletion occurring in any of the fisheries of the past five years, with no decline in CPUE as removals have accumulated. In 2012, fishery CPUE remained at about 500 kg/hour while over 20,000 t of snow crab was removed.

Size distributions from at-sea sampling by observers remained platykurtic from 2005-07, with little change in shape and a primary mode at 110 mm CW (Fig. 132). During this time, a reduction in catch rates occurred for all sizes of legal-sized crabs. In 2008, there was a dramatic change in the size distribution, with the primary mode shifting to about 92-98 mm CW. This modal shift coincided with an increase in the magnitude of catch rates for crabs from about 80-98 mm CW, likely indicating the entry of a recruitment pulse into legal size. Since then, the mode has gradually progressed to about 101-104 mm CW and catch rates of all sizes of legal-sized crabs have increased. There appears to have been a continued slow progression of recruitment into the exploitable population. Observer sampling data indicate that a relatively large increase in CPUE in 2010 was largely due to an increase in new-shelled legal-sized crabs (Fig. 133), which has since remained similar in magnitude. The 2012 increase in CPUE was due to increased catch rates of old-shelled crabs, which now comprise a higher proportion of the population. This may indicate that most of the recent recruitment pulse has now contributed to the exploitable biomass but also suggests the accumulation of a healthy residual biomass in this area.

The trawl survey index of exploitable biomass declined from 2009 to 2011 and changed little in 2012 (Table 7, Fig. 134). Traps and trawls have different catchabilities for different components of the population. The index from the trap survey, which tends to capture older-shelled crabs relatively better than new-shelled crabs in this area, peaked two years later in 2011 and changed little in 2012. The decline in the trawl survey index, which is driven by new recruitment, implies that the exploitable biomass has recently declined. This would suggest that the residual component of the exploitable biomass, as reflected in the trap survey index, will also be expected to decline soon. Spatially, there has been little change in the distribution of exploitable

crabs captured in the trawl survey in recent years, with highest catch rates occurring along the northern portion of the Grand Bank and along the Div. 3N slope (Fig. 135), consistent with the spatial pattern of fishery performance (Fig. 129). **Production**

Recruitment

Recruitment has recently peaked and will likely decrease in the short term (2-3 years). The high level of pre-recruit biomass indices from both trap and trawl surveys during 2008-10 (Table 7, Fig. 136) reflects the prominence of a group of large adolescents in both in the trap and trawl survey size frequency distributions in those years. The sharp decrease in the pre-recruit biomass index from both surveys in 2011 reflects the progression of that modal group into legal size. Most adolescents of this recruitment pulse have now recruited to the exploitable biomass as terminally-molted adults. The decline in pre-recruit crabs during the past two years has occurred throughout the area, with only a few localized areas producing large catches of pre-recruits in the trawl survey during the past two years (Fig. 137).

The trap survey captures older-shelled crabs relatively better than new-shelled crabs in this area. For example, the biomass of new-shelled crabs in the trawl survey has been higher than intermediate and old-shelled crabs each year since 2007 (Fig. 138), by a factor of 1.5 to 3 each year, while the ratio of new-shelled to older-shelled crab catch rates in the CPS trap survey has been about 1:1 each year since 2007 (Fig. 139). This likely reflects a competition effect for baited traps, with newer-shelled crabs outcompeted by older-shelled crabs. In this regard, the trawl survey, which utilizes more stages of relative shell age than the trap survey likely gives a truer depiction of the demographic structure of crabs in the population. The catch composition of exploitable crabs in the trawl survey shows that a trend of increasing levels of new-shelled males (immediate recruits) that began in 2007 peaked in 2009, declined to 2011, but increased again in 2012 (Fig. 138). The 2009 peak was followed by an increase in intermediate-shelled crabs that began in 2009, peaked in 2010, and declined gradually since. The more spatially limited CPS trap survey catch rates of new-shelled legal-sized males shows a similar phenomenon of an increase from 2007-09, but in that survey the abundance of new-shelled males has continued to increase each year (Fig. 139). The catch rate of old-shelled crabs in the CPS survey has remained relatively consistent at 6-7 kg/trap since 2006 but decreased in 2012.

The modal group of adolescents contributing to the high pre-recruit biomass index from 2008-10 is readily apparent in both trawl and trap survey size frequency distributions (Figs. 140-141). The sharp decrease in pre-recruit biomass index from both surveys in 2011 reflects the progression of that modal group to legal size, with most adolescents of this pulse now present in the exploitable biomass as terminally-molted adults. Small-mesh trap size frequencies from the CPS survey tracked the progression of this modal group of adolescents from about 41 mm modal CW in 2005 to 89 mm CW in 2010 (Fig. 142). The emergence of another group of small adolescents ranging from about 35-50 mm CW in 2012 could signify the start of another recruitment pulse. However, these crabs were only captured in one localized location in Div. 3LNO offshore, thus more years of data are needed to determine the validity of this signal.

Observer discard data are consistent in showing the deterioration of the recent recruitment pulse, with a decrease in the amount of under-sized crabs discarded during past two years (Fig. 143), following the elevated 2008-10 levels. Furthermore, a higher proportion of under-sized crabs captured in both the fishery (Fig. 144) and CPS trap survey (Fig. 145) have been old-shelled in recent years, reflecting a higher proportion of terminally-molted adults in this size group.

A decline in recruitment in the short term is consistent with the expected negative effect of a very warm oceanographic regime during 2004-06 on early survival and subsequent recruitment (Figs. 146-147), expected to impact the fishery at a lag of 9-10 years (Fig. 146). This effect of

ocean climate would first be expected to impact the exploitable biomass at a lag of about 7 years (i.e. 2011), consistent with the decline in the exploitable biomass index from the trawl survey in the past two years (Fig. 134). The difference in time necessary for the effects to be felt in the fishery relates to the selectivity of older-shelled crabs by baited traps. A residual biomass of large older-shelled crabs has been established in the past few years that is contributing to increasing trends in fishery (Fig. 126) and trap survey (Fig. 134) catch rates indices while the less discriminatory trawl-survey exploitable biomass index is in decline (Fig. 134), reflecting the diminishing contribution of newer-shelled crabs in the population.

Long-term recruitment prospects are unfavourable due to a recent warm oceanographic regime. The ocean climate indices imply some variability in recruitment beyond the short term (Figs. 146-147). However, the overall trend is warming, with record warm conditions in 2011.

Reproduction

The abundance of mature females has been at its lowest level for three consecutive years (Fig. 148). The percentage of mature females carrying full clutches of viable eggs has exceeded 80% from 2002-10 but decreased sharply to 60% in 2011 and 2012 (Fig. 148). It is unknown what effect, if any, a reduced level of abundance and/or fecundity will have on future stock productivity as it is not known to what extent larval supply regulates stock size.

Mortality

Exploitation

The exploitation rate index increased during the past two years following a sharp decrease from 2008 to 2010 (Fig. 150). Maintaining the current level of removals would likely result in little change in the exploitation rate in 2013.

Indirect Fishing Mortality

The pre-recruit fishing mortality rate index decreased from 2008 to 2011 but increased in 2012 (Fig. 150). The percentage of the total catch handled and released in the fishery (Fig. 150) decreased from 2008 to 2011 but increased in 2012, implying a potential decrease in pre-recruit mortality.

The threshold for soft-shell crab closures was changed from 20% to 15% in 2009 in Div. 3LNO (Fig. 151). The prevalence of soft-shelled crab in the catch throughout the season is typically negligible until mid to late June (i.e. week 12) (Fig. 151), later than in Div. 3K (Fig. 76). Soft-shell crab prevalence tends to increase slightly near the end of the season each year but does not commonly approach levels to invoke fishery closures.

Natural Mortality (BCD)

Bitter crab disease generally occurs at lower levels in Div. 3L than in Div. 3K, and has been virtually non-existent in Div. 3NO. Prevalence (in new-shelled males) from offshore Div. 3L fall multi-species trawl surveys (Fig. 152) has been variable, with highest incidence during 2003-2005. The high prevalence levels during 2003-05 were likely reflective of a high density of 40-75 mm CW crabs, which subsequently materialized into the recent recruitment pulse that has entered into the exploitable biomass. The lower prevalence levels of recent years are consistent with the decreased short and long-term recruitment prospects resulting from a warming oceanographic regime

DIVISION 3L INSHORE

The Fishery

The Div. 3L inshore fishery occurs in coastal bays and near-shore regions of the east coast, within 25 nm of headlands (Fig. 153) It incorporates CMAs 5A, 6A, 6B, 6C, 8A, and 9A. All but CMAs 6C and 8A are further sub-divided into inner and outer management areas. Landings increased by 19% from 6,100 t in 2005 to 7,300 t in 2010, and have since changed little, at 7,400 t in 2012 (Table 6, Fig. 154). Effort increased by 24% from 2008 to 2010 but has since declined by 22% (Table 6, Fig. 154). Catch per Unit Effort increased sharply in 2012 to its highest level since 1995, after varying about the long term average for the previous 5 years (Table 6, Fig. 155). There has been little change in the distribution of the fishery over the past four years (Fig. 156), but subtle changes include a reduction of effort in the outer portion of Bonavista Bay (CMA 5A) in the past two years, and the emergence of effort in the outer portion of St. Mary's Bay (CMA 9A) coupled with a reduction of effort inside the Bay since 2009. Most of the bays and coastal areas of Div. 3L receive considerable fishing effort each year, with little room for expansion within most CMAs. The temporal distributions of the 2011 and 2012 fisheries were the earliest in the past five years (Fig. 157), with the fishery commencing in mid-April and most effort expended by about the end of June (i.e. week 12).

Biomass

Catch per Unit Effort increased to its highest level since 1995 in 2012 (Table 6, Fig. 155). This increase reflects increased catch rates throughout most of the Division (Fig. 158). All bays, particularly the outer portions of them, had relatively high catch rates in 2012. This is indicative of an overall broad-scale trend that has occurred throughout the offshore region of Div. 3LNO as well (Fig. 129).

A high level of bias created by spatiotemporal inconsistency in the distribution of observer coverage among the many CMAs in the inshore (Fig. 159) creates uncertainty in observer-based CPUE at the divisional level, and does not allow for interpretation of observer-based CPUE in some individual CMAs. It also creates gaps in some years within CMAs where data series' are usually adequate for analysis (Fig. 160). In the past three years the spatial coverage of observer deployments across CMAs has improved, with all management areas receiving coverage at more proportional levels. However, the level of variability that still remains in annual coverage compromises the integrity of observer data as the basis for reliable fishery and resource performance indicators.

There has been a general inverse relationship between the areal extent of the fishery and commercial CPUE since 1995 (Fig. 161). The sharp increase in CPUE in 2012 was opposed by a reduction in areal extent of the fishery. However, overall there has been limited change in the spatial extent of the fishery since 2002. The areal distribution consists of two distinct levels, with about 30-45% of available 5' x 5' cells occupied each year from 1995-2001 and about 70-80% of cells occupied each year thereafter. This is attributable to an expansion of effort throughout the inshore of Div. 3L beginning in 2002, which was most pronounced in coastal regions of the Northeast Avalon and the western half of Conception Bay (Dawe et al. 2003). This sharp increase in spatial coverage of the fishery in 2002 was followed one year later by a sharp decrease in CPUE (Fig. 161), and the fishery has only recently begun to experience catch rates comparable to the pre-expansion period.

Catch per Unit Effort indices have typically shown a pattern of depletion throughout the season in recent years (Fig. 162). Catch per Unit Effort tends to be greatest at the beginning of the season, ranging from about 12-16 kg/trap, and declines thereafter, generally finishing at less than 8 kg/trap (Fig. 162). With little exception, the 2012 fishery performed better throughout the

season than the 2009-11 fisheries in relation to both weeks (Fig. 162) and cumulative removals (Fig. 162).

The post-season trap survey index indicates the exploitable biomass increased in 2012 to its highest level in the time series (Fig. 163). The greatest increase occurred in Conception Bay (CMA 6B) where the index more than doubled in 2012, while more subtle changes occurred throughout the rest of the Division.

Production

Recruitment

Recruitment, as indicated by new-shelled legal-sized males, has recently peaked and is in decline, although there is considerable variability among management areas. Short-term (2-3 years) recruitment prospects are uncertain. The pre-recruit biomass index in this area (Fig. 164) is dominated by old-shelled crabs (Figs. 165-166) and their proportion has increased in recent years, especially in 2012 (Fig. 167). It is believed that most of those are terminally-molted adults that will never contribute to the exploitable biomass. The peak of new-shelled males into the fishery in 2010 was followed by an increase in old-shelled males, with the 2012 level the highest in the time series (Fig. 165). Similarly, a mode of new-shelled crabs present at 92 mm CW in 2010 and 2011 has now progressed into legal-size (Fig. 166). This is consistent with the most recent recruitment pulse now near-fully contributing to the exploitable biomass, as also seen in the offshore (Figs. 141-142). The high 2012 value in the pre-recruit biomass index (Fig. 164) is likely an artifact of a high abundance of small terminally molted (i.e. old-shelled) males (Fig. 166-167) in the population. It is possible that some of these crabs are skip-molters. Skip-molting is most common in large adolescents in cold conditions (Dawe et al. 2012a).

Mortality

Exploitation

The trap survey-based exploitation rate index changed little in 2012 but there was considerable variability among management areas (Fig. 168). Maintaining the current level of fishery removals would likely result in a decrease in the exploitation rate in 2013.

Indirect Fishing Mortality

Spatiotemporal inconsistencies in the distribution of observer coverage do not allow for a reliable index of discards at the divisional level. Data are insufficient to estimate the pre-recruit fishing mortality rate index.

Natural Mortality (BCD)

The trend in prevalence of BCD from the DFO trap survey in Conception Bay (Fig. 169) was somewhat similar to that from the multi-species trawl surveys throughout offshore Div. 3L (Fig. 152), but at higher levels of prevalence, with highest prevalence during 2004-05. Prevalence generally increased to 2000 before decreasing sharply in 2001. It increased during 2002-05 before decreasing to 2007 and remained low since. The elevated prevalence levels of 2003-06 are consistent with the subsequent improvements in exploitable biomass and fishery performance in recent years.

Spatial Variability: Trends by CMA

CMA 5A (Bonavista Bay)

Fishery CPUE increased in 2012 following a substantial decline from 2008-11. However, CPUE remains relatively low (Fig. 160), consistent in both logbook and observed catch rates. The TAC was reduced in 2011 as catch rate declined (Fig. 160) and effort peaked (Fig. 170). The

reduced TAC has been taken during each of the past two years, with much less effort required to do so in 2012 (Fig. 170). Observer sampling shows that the 2008-11 catches were dominated by old-shelled crabs, following a peak of new-shelled legal-sized crabs in 2007 (Fig. 171). The increased CPUE in 2012 was due almost entirely to an increased catch rate of new-shelled legal-sized crabs, reflecting increased recruitment into the exploitable biomass for the first time in several years. This is further evident in observer size frequency distributions, which showed virtually all crabs captured were old-shelled during 2010-11 (Fig. 172) and new-shelled in 2012. The increased presence of new-shelled crabs in the fishery in 2012 is consistent with the 2011 CPS and DFO trap surveys, which both showed a sharp increase in new-shelled legal-sized crabs available after the 2011 fishery (Figs. 173-174). This improved signal of immediate recruitment available to the fishery was only marginally decreased in 2012, implying relatively positive short-term recruitment prospects. Large-meshed trap size frequency distributions from the CPS survey have been dominated by new-shelled crabs for each of the past two years and showed a modal shift from 92 mm CW in 2011 to 104-107 mm CW in 2012 (Fig. 175). This may indicate that the recruitment pulse is now fully contributing to the exploitable biomass. This recent recruitment pulse was evident in small-meshed trap size frequency distributions in 2011 as a large mode of adolescents centered at about 92 mm CW. The relatively rapid dissipation of this pulse of adolescents in 2012 suggests reduced recruitment prospects beyond the short-term, but another survey year is needed to verify. Data from size frequency distributions in trawls in the DFO survey are not useful in 2012 because of a change in vessel, with the new vessel exhibiting a higher catchability of snow crab in the survey trawl than the old vessel as seen by increased catch rates of crab across the entire size range (Fig. 177). Observer sampling of under-sized crabs has shown generally low levels of new-shelled under-sized crabs in the population in recent years (Fig. 178), consistent with the notion that the recent recruitment pulse quickly moved through this size range of crabs. Observer sampling indicates that the majority of discards in the fishery have been undersized crabs in recent years (Fig. 179), although there may have been a small increase in soft-shell in the catch in 2012 (Fig. 180). However, the overall impression is that the recruitment pulse has been allowed to enter into the exploitable biomass with little fishery-induced mortality.

CMA 6A (Trinity Bay)

Logbook and observed CPUE both increased since 2008 (Fig. 160), which was associated with a reduction in effort and, in the past 3 years, increased TACs and removals during the past three years and a decreasing trend in effort since 2005 (Fig. 181). Observer sampling indicates that the improved CPUE was attributable to an increase in legal-sized old-shelled crabs in 2009-10 and new-shelled legal-sized crabs in the past two years (Figs. 182-183). However, the scenario of a population dominated by old-shelled crabs in 2009-10 does not fit with an increasing biomass, as it does not imply increasing recruitment and there was no evidence of a high level of new-shelled crab in 2007-08 (Fig. 182). Accordingly, there is skepticism associated with observer shell condition classification in this area. However, there is the suggestion of modal progression in observer size frequency distributions from about 92 mm CW in 2009 to 101 mm CW in 2010-11 and to 104-110 mm CW in 2012, indicative of a recruitment pulse gradually entering into legal size and consistent with the improving fishery performance. The CPS trap survey indicates a reduction in the exploitable biomass remaining after the fishery in the past two years (Figs. 184-185), attributable to reduced catch rates of new-shelled legal-sized crabs. Small-mesh size frequency distributions in the CPS survey (Fig. 186) indicate that a recruitment pulse that had been tracked as small adolescents since 2005 dissipated after 2010 and is now fully contributing to the exploitable biomass, consistent with the recent improvements in fishery performance but suggestive of a reduced level of recruitment moving forward. Inferring recruitment potential from shell condition classification of under-sized crabs in this area (Fig. 187) is not useful due to concerns with the observer shell-condition classification

previously described, but a reduction in under-sized crabs in the catch, as well as a low level of soft-shelled crabs during the past two years (Figs. 188-189), would imply low short-term recruitment potential. Although mortality rates appear to have been lower in the past two years than previously, indicated by reduced soft-shell prevalence (Figs. 188-189), most data indicate the exploitable biomass has probably peaked and reduced recruitment prospects can be expected moving forward.

CMA 6B (Conception Bay)

Commercial CPUE has increased since 2005, based on both logbook and observer indices (Fig. 160). The increases in CPUE occurred concurrent with increases in TACs and landings and reductions in effort (Fig. 190). Observer sampling shows that the increasing CPUE was initially attributable to new-shelled legal-sized crabs from 2006-08 and more recently to increasing abundance of old-shelled legal-sized crabs (Figs. 191-192). However, the new-shelled component of the population increased again in 2012. Both components of the population increasing together like this are indicative of a growing exploitable biomass. This can be seen in observer size frequency distributions (Fig. 192), which show an overall increasing catch rate of both shell condition components of most sizes of legal-sized crabs since 2007. The CPS (Fig. 193) and DFO (Fig. 194) trap surveys both showed that the new-shelled component last peaked in 2009 and has since been followed by large increases in the old-shelled component of the exploitable biomass, especially in 2012. Size frequencies from large-meshed traps in the CPS survey show increased levels of sub-legal-sized crabs, ranging from about 83-92 mm CW, in the past four years (Fig. 195). This is consistent with small-mesh traps in both the CPS (Fig. 196) and DFO (Fig. 197) surveys, all of which indicate that the build-up of sub-legal-sized crabs is primarily a function of terminally molted adults. Such a scenario would not be expected to result in increases in the exploitable biomass, thus it appears possible that a competition effect for baited traps is occurring in the sub-legal-sized component of the population, with large-clawed (i.e. adult) males outcompeting small-clawed (i.e. adolescent) males for the traps. Consistent with this idea, size frequency distributions from trawl surveys show that the majority of sub-legal-sized crabs have been adolescent in recent years (Fig. 198). The big mode of large adolescents evident in trawl surveys for each of the past six years is consistent with a growing exploitable biomass, but a lack of progression suggests catchability issues with that survey gear as well. Data from the 2012 trawl surveys are deemed incomparable with previous years due to a change in survey vessel. Observations from Bonavista Bay (Fig. 177) suggested the new vessel had a higher catchability for snow crabs than the old vessel. Also consistent with the idea of a competition and selectivity effect for baited traps, observer sampling has shown that the majority of under-sized crabs captured in the fishery have been old-shelled (Fig. 199), which implies they are terminally molted adults. Observed discards in the fishery are dominated by under-sized crabs in most years (Fig. 200) and show a consistent level of about 3 kg/trap discarded since 2003. The fishery appears to have imposed minimal mortality on the population in terms of soft-shell discarding in recent years (Fig. 201), and natural mortality resulting from infection with BCD has been low relative to the high 2003-07 levels (Fig. 169). The elevated 2003-07 BCD levels are consistent with a pulse of recruitment progressing through the population which has subsequently resulted in the high exploitable biomass now present. However, the subsequently reduced levels imply lower recruitment prospects moving forward. Nonetheless, most data are consistent in showing the present exploitable biomass to be high in Conception Bay.

CMA 6C (Northeast Avalon)

Fishery CPUE increased substantially during the past two years (Fig. 160) while the TAC has remained unchanged and landings increased only marginally (Fig. 202). The effort expended in 2012 was the lowest level seen since the early 2000s. The increase in CPUE is reflected by an

increase in catch rates of legal-sized crabs in the CPS survey (Figs. 203-204). The survey catch rate improvements have been attributable to increasing recruitment in the form of new-shelled crabs, as old-shelled crab catch rates have been constant since 2008. A variable but high proportion of pre-recruit-sized crabs in the CPS survey small-meshed trap catches have been terminally molted adults during the past six years (Fig. 205), thus they are uninformative as an indicator of long-term recruitment prospects. The limited data available for CMA 6C infer positive fishery prospects for 2013 (Fig. 203) with no information available on longer-term prospects.

CMA 8A (Southern Avalon)

At 18-22 kg/trap, fishery CPUE has remained relatively high and consistent since 1994 (Fig. 160) while TACs and landings have been increasing (Fig. 206). The small CPUE spikes in both 2008 and 2011 followed spikes in new-shelled legal-sized crabs in the CPS trap survey (Fig. 207). These new-shelled spikes were followed by subsequent increases in old-shelled legal-sized crabs in both cases. Most recently, it appears that a recruitment pulse entered into the exploitable biomass in 2010, in the form of soft- and new-shelled crabs (Fig. 208), and the resultant residual biomass of old-shelled crabs has been subsequently eroded by the fishery during the past two years. Overall, the variable nature of the trap survey performance each year, in both sub-legal and legal-sized crabs (Fig. 207), renders predictions about recruitment prospects difficult but there have been no positive signals of forthcoming recruitment during the past two years.

CMA 9A (St. Mary's Bay)

Commercial CPUE has varied between about 15-23 kg/trap since 1999 (Fig. 160), with a sharp decline in 2008 followed by a slight increase from 2009-12. The slight increase in CPUE in recent years has been associated with historically high TACs and landings (Fig. 209). Observer sampling indicates a build-up of small legal-sized crabs in the past three years (Figs. 210-211). However, the old-shelled nature of the population is not consistent with the emergence of a recruitment pulse into legal-size, thus there is skepticism associated with observer shell classification in this area. The CPS trap survey shows the legal-sized population was dominated by new-shelled crabs in 2010-11 (Fig. 212), with a tripling in catch rates of new-shelled legal-sized crabs from 2008-10. This has since resulted in an increase in catch rates of old-shelled crabs in 2012 (Fig. 212). This indicates the emergence of a recruitment pulse into legal-size, evident in size frequency distributions (Fig. 213). The majority of this recruitment pulse is now contributing to the exploitable biomass, with few under-sized soft- or new-shelled crabs captured in 2012. The progression of this recruitment pulse was tracked since 2009 in small-mesh traps in the CPS survey (Fig. 214), with the dissipation of the adolescent signal in 2012 supporting the notion that the majority of the recruitment pulse has now entered into the fishery. Further support is provided by the reduction in observed catch rates of under-sized crabs in the 2012 fishery relative to the level seen from 2009-11 (Fig. 215). Observer data indicate that soft-shelled crab has been a minimal issue in St. Mary's Bay in recent years (Fig. 216), inferring that the recruitment pulse has been allowed to enter into legal-size with minimal fishery-induced mortality. Overall, fishery prospects appear positive for 2013 (Fig. 212), but recruitment prospects will likely deteriorate in the short-term, and longer-term prospects are uncertain.

SUBDIVISION 3PS OFFSHORE

The Fishery

The Subdiv. 3Ps offshore fishery occurs off the south coast of Newfoundland in areas associated with the St. Pierre and Green Banks (Fig. 217). It incorporates CMAs 10BCD, 10X, 11S, and 11Sx. Landings (Table 8, Fig. 218) almost doubled from 2,300 t in 2006 to a peak of

4,300 t in 2011, before decreasing by 14% to 3,700 t in 2012. Effort (Table 8, Fig. 218) increased by 57% from 2008 to 2011 before decreasing slightly in 2012. Catch per Unit Effort declined substantially from 1999 to 2005 (Table 8, Fig. 219). It increased from 2005 to 2009 and has gradually declined since. There is strong agreement among all three indices on the trend in CPUE since 2004.

The spatial distribution of the fishery has remained similar over the past four years (Fig. 220) but there have been some subtle changes. In most years, the bulk of fishing effort is expended in Halibut Channel between the St. Pierre and Green Banks (Fig. 220). In 2010-11, the effort became more highly concentrated in the northern portion of Halibut Channel than in most previous years. The effort on the slope edge along the northwest portion of the St. Pierre Bank has also increased during the past five years. Finally, a pocket of effort emerged in a previously un-fished area in shallow water along the southern tip of the St. Pierre Bank in 2012. The fishery in Subdiv. 3Ps offshore tends to occur earlier than in northern divisions due to a lack of spring ice coverage off the south coast. The temporal distribution of the 2012 fishery was earlier than in 2010 and 2011, beginning in the first week of April and most effort was expended by early June (i.e. week 10) (Fig. 221).

Biomass

Declines in CPUE occurred throughout the offshore in the past two years but have been most extreme in the furthest offshore areas (Fig. 222). The offshore fishery has performed much worse than the inshore fishery in recent years. The spatial coverage of the fishery has generally been inversely related to commercial CPUE since 1999 (Fig. 223). 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 but has since steadily increased to a recent high. This indicates an increased element of searching activity by harvesters in recent years.

Catch rates have shown high levels of weekly variability, but generally show a pattern of the fishery performing poorer throughout the duration of the season in the past two years than it did in the previous three (Fig. 224). In terms of cumulative removals, the 2012 fishery performed most poorly within the five year time series, particularly during the mid to late portions of the season (Fig. 224).

Size distributions from at-sea sampling by observers (Fig. 225) showed a sharp ('knife-edge') decrease in catch rate at 95 mm CW from 2005-07, suggesting high fishery exploitation on legal-sized crabs in those years. This knife-edge effect was not present in 2008-11, with increased catch rates of most sizes of legal-sized crabs, but re-emerged in 2012 as catch rates of most sizes of legal-sized crabs decreased. The reduced catch rates in 2012 were most apparent in crabs ranging from about 95-107 mm CW.

The observed catch rate of legal-sized new-shelled crabs decreased sharply in 2001, followed by a sharp decrease in catch rate of legal-sized old-shelled crabs in 2003 (Fig. 226). 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 virtually nil each year after 1999, with the exception of 2005. Both the new- and old-shelled components of the population have gradually declined in recent years from a 2009 peak in old-shelled crabs and a 2010 peak in new-shelled crabs.

The exploitable biomass, as indicated by both the spring trawl survey and the post-season trap survey indices, increased steadily from 2006 to 2009 before declining sharply from 2009 to

2011, and changed little in 2012 (Table 9, Fig. 227). Both surveys indicate the biomass decreased throughout the area in 2012, with the exception of the boundary with the inshore area to the north. This is especially apparent in the trawl survey, which has captured very few exploitable crabs anywhere in the offshore during the past two years (Fig. 228). Of particular concern is the dissipation of catch rates in the Halibut Channel between the St. Pierre and Green Banks, a normally productive area.

Production

Recruitment

Recruitment has recently declined and is expected to decline further in the short term (2-3 years). Pre-recruit biomass indices from both trap and trawl surveys declined sharply from 2009-11 and changed little in 2012 (Table 9, Fig. 229). Similar to exploitable crabs, there is a general pattern of decreasing catch rates of pre-recruit crabs with distance from shore in the trawl survey. Very few crabs were captured in any offshore area in the past two years, including Halibut Channel (Fig. 230).

This recent decline in recruitment is reflected in a decrease in biomass of new-shelled legal-sized crabs beginning in 2010 and the subsequent decrease in older-shelled crabs in 2011-2012. This phenomenon is apparent in data from both the trawl (Fig. 231) and the CPS trap (Fig. 232) surveys.

Size distributions from the spring trawl survey showed a modal group of adolescent crabs approaching legal-size in 2007-09 that has since dissipated (Fig. 233). The advancement of this recruitment pulse into legal-size is also reflected in CPS trap survey size frequencies (Fig. 234), which showed an increasing abundance of new-shelled crabs ranging from about 95-110 mm CW during those years and a subsequent decline. The 2012 size frequency distribution portrays a greatly reduced abundance of all sizes of legal-sized crabs in Subdiv. 3Ps offshore.

Small-meshed size frequency distributions from the CPS survey clearly show the high proportion of small terminally-molted adults that characterizes this area (Fig. 235). This is attributable to the very cold bottom water conditions here, with most crabs terminally molting at small sizes under cold conditions (Dawe et al. 2012a). These size frequencies show few under-sized adolescents remaining in the population in recent years.

At-sea observer data show that virtually all discards in the fishery have been under-sized crabs since 2005 (Fig. 236), with no indication of soft-shelled crabs in the catch. This infers a relatively low level of fishery-induced mortality on pre-recruits. These in-season measurements show a gradual decrease in catch rate of under-sized crabs since 2006 (Fig. 236), consistent with the scenario of decreasing recruitment potential in this area. Further supporting the idea of a forthcoming decline in recruitment is the increasing proportion of pre-recruit-sized crabs that are old-shelled and are not likely to molt again. This trend has occurred since the mid-2000s in both the within-season observer data (Fig. 237) and the post-season trap survey (Fig. 238).

Fishery CPUE is inversely related to a lagged (seven year) index of bottom temperature at shallow depths in offshore Subdiv. 3Ps and directly related to the spatial extent of <1 °C water (i.e. habitat index) at the same lag (Fig. 239). Similarly, the shorter time series of the exploitable biomass index shows a lagged negative relationship with bottom temperature and a lagged positive relationship with the habitat index at six years (Fig. 240). These ocean climate indices imply some variability in recruitment beyond the short-term. However, the overall trend is warming, with near record warm conditions in 2011. Consistent with the broader-scale trend of ocean climate across the entire Newfoundland and Labrador shelf, long-term recruitment prospects are unfavourable due to a recent warm oceanographic regime.

Reproduction

The abundance of mature females captured in the spring trawl survey increased sharply in 2002, and has since declined. The index has been a very low level in the past two years (Fig. 241). This reduction in abundance of mature females has occurred throughout the offshore (Fig. 242). There is high annual variability in the percentage of females carrying full clutches of viable eggs (Fig. 241). Greater than 90% of females carried full clutches of eggs from 2008-10, but only 70% carried full viable clutches in the past two years. The reasons for the negative trends in abundance and clutches of mature females in recent years are unknown, and it remains unclear if they will have an effect over future stock productivity.

Mortality

Exploitation

The exploitation rate, as indicated by the spring trawl survey index, decreased from 2007-09 but increased sharply to 2011 and changed little in 2012 (Fig. 243). Maintaining the current level of fishery removals would likely result in little change in the exploitation rate in 2013.

Indirect Fishing Mortality

The pre-recruit fishing mortality rate index, as indicated by the spring trawl survey index, decreased from 2007-09 but increased sharply to 2011 and changed little in 2012 (Fig. 243). The percentage of the total catch discarded in the fishery (Fig. 243) peaked at about 45% in 2005, declined by half to 2008, and has since changed little. This implies little change in wastage of pre-recruits in recent years. Thus, the increase in the PFMI in 2010 and 2011 reflects the declining pre-recruit biomass more than increased discard levels of under-sized crabs. The percentage of the catch discarded in Subdiv. 3Ps is generally higher than in other divisions as it includes a larger component of under-sized crabs, an unknown but high portion of which is comprised of small adults that will never recruit to the fishery. Soft-shelled crab has been virtually absent in the observed catch in most recent years but increased in the latter parts of the 2011 and 2012 seasons, with weekly prevalence of 5-10% late in the season of those years (Fig. 244).

Natural Mortality (BCD)

Small-meshed trap data from the CPS trap survey indicates that BCD has been detected, at low prevalence levels in offshore Subdiv. 3Ps in 2005-06, but not in 2007-12 (unpublished data).

SUBDIVISION 3PS INSHORE

The Fishery

The Subdiv. 3Ps inshore fishery occurs in near-shore regions off the south coast of Newfoundland (Fig. 245). It incorporates CMAs 10A, 11E, and 11W. Placentia Bay (CMA 10A), to the east of the Burin Peninsula constitutes the primary fishing grounds. Landings (Table 8, Fig. 246) peaked at 3,500 t in 1999, declined to 700 t in 2005, then more than tripled to 2,500 t in 2012. Effort (Table 8, Fig. 246) declined from 2005 to 2010 and increased by 36% to 2012. Catch per Unit Effort (Table 8, Fig. 247) declined from 2001-05, increased steadily to 2010, its highest level since 1996, and has since changed little.

The spatial distribution of the fishery has changed little over the past five years with only subtle annual changes (Fig. 248). Most effort is expended in Placentia Bay (CMA 10A, Fig. 245) with Fortune Bay (CMA 11E, Fig. 245) representing a secondary source of effort. The commercial fisheries in CMAs 11E and 11W were closed in 2005 but re-established in 2011. A small-scale monitoring fishery occurred each year in the interim. Within CMA 11E there has been an

emergence of effort in a coastal fjord in the northwest of the management area since 2007 (Fig. 248) while effort in CMA 11W has been variable, being virtually non-existent from 2006-09, with light effort since (Fig. 248). Meanwhile, a small fleet allocated quota on the northwest portion of the St. Pierre Bank that did not fish that area from 2006-08 has resumed fishing along the slope edge of the St. Pierre Bank during the past four years (Fig. 248). Temporally, similar to the offshore, the 2012 fishery was early relative to the previous two years. There was a considerable level of effort expended upon opening in the first week of April (i.e. 15% total season trap hauls) and the fishery was near completed by about the end of May (i.e. week 8). As in the offshore, the management shift toward a spring fishery has been more successful in Subdiv. 3Ps inshore than in other divisions, likely attributable to the lack of spring ice cover.

Biomass

There has been little change in CPUE throughout most of the inshore during the past four years (Fig. 250). Placentia Bay has consistently performed best but all inshore fishing areas have generally performed better in the past four years than in 2007-08. A high level of bias created by spatial and temporal inconsistency in the distribution of observer coverage among the various CMAs (Fig. 251) creates uncertainty in observer-based CPUE at the sub-divisional level, and especially compromises interpretation of CPUE at the CMA level (Fig. 252). In recent years, the distribution of observer coverage between Placentia (CMA 10A) and Fortune (CMA 11E) Bays has been highly inconsistent. For example, virtually all observer coverage occurred in Placentia Bay from 2006-08 but Fortune Bay received the bulk of coverage in 2009 and a relatively even split of observer coverage between the two areas in 2010 was followed by disproportionate coverage in Placentia Bay in 2011 (Fig. 251). In 2012, CMA 11W received coverage for the first time in many years. This spatial bias is further compounded by temporal inconsistencies within season in each CMA from year to year, further compromising the utility of inshore observer data for stock assessment purposes.

The spatial coverage of the fishery has been inversely related to commercial CPUE since 1995 (Fig. 253). With about 14-16% of the grounds covered, the percentage of available 5' x 5' cells occupied by the fishery has been unchanged in the past four years while CPUE has exhibited subtle changes.

Trends in commercial CPUE throughout the season (Fig. 254) indicate that in 2012 CPUE remained similar to that of the previous three years and higher than during 2008 throughout the season. Similarly, 2012 catch rates remained comparable to the previous three years, and well above 2008 levels, when measured against cumulative catch (Fig. 254). There has been no sign of resource depletion, as indicated by seasonally declining fishery catch rates, in recent years.

The exploitable biomass, as indicated by the post-season trap survey index, increased substantially between 2006 and 2010 and has since changed little (Fig. 255). Most of the biomass is in Placentia Bay (CMA 10A).

Production

Recruitment

Recruitment has recently decreased. The index of pre-recruit-sized males has recently decreased (Fig. 256), suggesting a further decline in recruitment in the short term (2-3 years). However, this index includes a high and increasing proportion of small adults in this area that will never recruit to the fishery. The abundance of new-shelled legal-sized males in the exploitable biomass has been highly variable in recent years but appears to have peaked in 2010 (Fig. 257). This is most readily apparent in size frequency distributions from large-mesh traps in the CPS survey (Fig. 258), which showed a build-up of new-shelled crabs ranging from

about 92-100 mm CW in 2010. The mode from that distribution has subsequently advanced from about 92 mm CW in 2010 to 104 mm CW in 2012, indicating that most of that recruitment pulse is now contributing to the exploitable biomass. Consistent with deteriorating short-term recruitment prospects, there has been a higher proportion of old-shelled pre-recruit-sized crabs in the population since 2010 than previous (Fig. 259). Longer-term recruitment prospects are uncertain.

Mortality

Exploitation

The post-season trap survey-based exploitation rate index changed little during 2008-11 but increased in 2012 (Fig. 260). Maintaining the current level of fishery removals would likely result in little change in the exploitation rate in 2013.

Indirect Fishing Mortality

Spatiotemporal inconsistencies in the distribution of observer coverage do not allow for a reliable index of discards at the Divisional level. Data are insufficient to estimate the pre-recruit fishing mortality rate index.

Natural Mortality (BCD)

Small-meshed trap data from the collaborative post-season trap survey indicates that BCD was occasionally detected, at low levels prior to 2004 in inshore Subdiv. 3Ps, but absent since (unpublished data).

Spatial Variability: Trends by CMA

CMA 10A (Placentia Bay)

Fishery performance improved substantially from 2006-10 and remained high since, as indicated by both logbook and observer CPUE indices (Fig. 252). This trend coincided with increased TACs and removals during the same time frame (Fig. 261). Observer sampling indicates that the abundance of both new-shelled and old-shelled exploitable crabs increased from 2006-2011, with the new-shelled component decreasing in 2012 while the old-shelled component increased further (Fig. 262). This suggests recruitment may have peaked. Size frequency distributions from observers showed a relatively high proportion of new-shelled crabs at all sizes in 2010 and 2011, but old-shelled crabs dominated the entire size distribution in 2012 (Fig. 263). A mode of under-sized new-shelled crabs present at 92 mm CW in 2010 advanced into legal-size at about 101 mm CW in 2011, with the new-shelled signal dissipating in 2012. The CPS trap survey similarly indicates that recruitment has peaked, with the highest abundance of new-shelled legal-sized crabs occurring in 2010 and reductions in new-shelled abundance and increases in old-shelled abundance since (Fig. 264). There was no signal of under-sized new-shelled crabs in the size frequency distributions during the past two years (Fig. 265). Small-mesh traps in the CPS survey are not useful in interpreting recruitment prospects due to the dominance of under-sized adults in the catch (Fig. 266) but observer sampling indicates a substantial increase in the proportion of under-sized crabs that were old-shelled in the past two years (Fig. 267) along with an overall decreased catch rate of under-sized crabs (Fig. 268), signaling reduced short-term recruitment prospects. The recruitment pulse(s) that have entered into the exploitable biomass in recent years have been subject to minimal fishery-induced mortality in the form of soft-shell discards (Fig. 268-269). Overall, all data are consistent in indicating an expected short-term resource decline while longer-term recruitment prospects are uncertain.

CMA 11E (Fortune Bay)

CPUE has been in a variable, but overall gradually increasing, trend since 2003 (Fig. 252). Landings have also been variable, but showed an overall increase from 2008-2012 (Fig. 270), while effort has been constant. Observer data show a marked increase in the abundance of new-shelled legal-sized crabs in the past three years (Figs. 271-272), indicative of increased recruitment into the exploitable biomass. The CPS trap survey has shown a similar trend, with increasing recruitment during the past three years (Fig. 273). However, the DFO trap survey suggests recruitment may have peaked in 2011, as indicated by a sharp spike in catch rates of new-shelled legal-sized males in the deepest stratum of the area (Fig. 274). Nonetheless, both surveys are consistent in showing an overall increased exploitable biomass in recent years that is predominately comprised of new-shelled crabs (Fig. 275). Small-mesh trap data from the DFO survey are not useful in helping predict long-term recruitment due to the dominance of small adults in the catch (Fig. 276), while trawls in the DFO survey appear highly inefficient at capturing crabs, with virtually nothing captured in 2012 (Fig. 277). Observer sampling indicates a roughly steady-state scenario in the proportion of under-sized crabs that are new-shelled (Fig. 278), as well as the catch rate of under-sized crabs in the fishery in most years (Fig. 279). However, both indices went down in 2012, suggesting a reduction in short-term recruitment prospects. The recruitment pulse that has entered into the exploitable biomass in recent years appears to have been subject to little fisheries-induced mortality in the form of soft-shell discards during most weeks of fishing (Figs. 279-280). Overall, most data indicate an improvement in resource status in recent years but both short- and long-term recruitment prospects appear less favourable.

CMA 11W (Pass Islands)

Commercial CPUE initially peaked at 8 kg/trap in 1998, and declined to a low of 2 kg/trap in 2003 (Fig. 252). It increased steadily, to a high of 11 kg/trap in 2009 and since decreased to a near-average level. Fishery landings have been steady at about 40 t during each of the past four years (Fig. 281) following virtual abandonment of the fishery from 2004-08. There is no available information from which to infer recruitment prospects.

DIVISION 4R3PN OFFSHORE

The Fishery

The Div. 4R3Pn offshore fishery occurs along the west coast of Newfoundland outside of eight nautical miles from the headlands (Fig. 282). The area comprises CMA OS8, and is characterized by a shallow water nearshore plateau that borders the deep Esquiman Channel to the west. Landings (Table 10, Fig. 283) declined substantially from 580 t in 2004 to 80 t in 2006 before more than doubling to 190 t in 2007. They then declined by 83% to a historical low of 30 t in 2010, but increased back to 190 t in 2012. Effort (Table 10, Fig. 283) increased by a factor of four in 2011 following the historical low in 2010 and changed little in 2012. The TAC has not been taken since 2002. Vessel monitoring system-based CPUE declined from 2004 to its lowest level in 2009 before increasing to the average of the series in 2012 (Table 10, Fig. 284). Catch per Unit Effort has consistently been low relative to other divisions.

The fishing pattern has highly aggregated in recent years. There have been three distinct concentrations of effort in the northern portion of the area, as well as a patch of effort in the central portion, since 2008, while effort in the southern portion of the area has increased in the past two years (Fig. 285). As in most other divisions, the 2012 fishery was slightly earlier than in recent years (Fig. 286). The fishery began in the first week of April and was almost finished by the end of May.

Biomass

There has been some spatial variability in CPUE in recent years but the general trend has been of a poorly performing fishery throughout the offshore since 2007 (Fig. 287). However, in 2012 there were improvements in catch rates in areas adjacent to the inshore management areas, particularly outside of Bay St. George in the south and outside CMA 12G in the north. In contrast to other divisions, CPUE and the spatial extent of the fishery have not shown a tendency to be negatively related over most of the time series (Fig. 288). Rather, they exhibit more of a direct relationship. We interpret this as reflecting an opportunistic fishery, with participation increasing when catch rates are good and abandonment occurring when catch rates are poor. The spatial extent of the fishery had decreased precipitously from 2000-10, as catch rates decreased (Fig. 284), to a low of only 5% of the grounds covered in 2010. However, more of the grounds have been fished in the past two years.

Commercial CPUE throughout the season was about average in 2012 in relation to the most recent five years (Fig. 289). However, in terms of the relationship with cumulative removals, the 2012 fishery performed better than it did in the previous four years. It maintained higher catch rates than in previous years up to a level of about 80 t of removals (Fig. 289).

Despite some subtle signs of improvements in the fishery the exploitable biomass remains low relative to other areas. There is high uncertainty in interpreting annual changes in exploitable biomass (Table 12, Fig. 290) because trawl survey catches are few and localized to the northern portion of the area (Fig. 291), and in both the trawl and trap surveys the variation among catches is high compared to the mean.

Production

Recruitment

Recruitment prospects are uncertain in the short term (2-3 years). In both surveys the variation among catches is high compared to the mean. This introduces high uncertainty in interpreting annual changes in pre-recruit biomass (Table 11, Fig. 292). Trawl survey catches are few and localized in the northern portion of the area (Fig. 293).

The CPS trap survey catch rate of new-shelled legal-sized crabs has varied at a very low level of 0-1 kg/trap over the 5-year time series (Fig. 294) and the trawl survey size frequencies (Fig. 295) are uninformative due to a scarcity of data. Similarly, large-meshed traps from the CPS survey are uninformative due to low and sporadic catch rates (Fig. 296) which do not allow for reliable inferences of recruitment prospects. For example, the index of pre-recruit-sized crabs that are old-shelled was one hundred percent in 2012 (Fig. 297), reflecting only three sub-legal-sized crabs captured in the survey (Fig. 296).

Long term recruitment prospects are unfavourable due to a recent warm oceanographic regime. CPUE in this, the warmest, area is inversely related to shallow-water bottom temperature five years earlier based on a 1989-2009 temperature series (Fig. 298). The bottom temperature data series for Div. 4R was only available up to 2009. However, a more recent temperature series from a nearby oceanographic station in NAFO Div. 4S trends similarly, was positively correlated with the bottom temperature trend observed in Div. 4R from 1989-2009, and shows steady warming since 2008 (Fig. 299).

Reproduction

Maturities were not assigned to females captured in the summer trawl survey, thus an index of abundance of large (>30 mm CW) females was developed as a proxy. This index showed high annual variability (Fig. 300), and catches in the survey trawl tended to be sporadic (Fig. 301). Thus, it was deemed uninformative.

Mortality

Data are insufficient to calculate exploitation rate and pre-recruit fishing mortality rate indices. The effect of maintaining the current level of removals on the exploitation rate in 2012 is unknown.

DIVISION 4R INSHORE

The Fishery

The Div. 4R inshore fishery occurs in bays and nearshore areas inside of eight nautical miles from the headlands along the west coast of Newfoundland (Fig. 302). It incorporates CMAs 12C, 12D, 12E, 12F, 12G, and 12H. Landings (Table 10, Fig. 303) declined by 80% from 950 t in 2003 to a historical low of 190 t in 2010. They more than doubled to 450 t in 2011 and increased further to 550 t in 2012. Effort (Table 10, Fig. 303) declined by 95% from 2004 to 2010 and doubled in 2011 before decreasing substantially in 2012. The TAC has not been taken since 2002. CPUE (Table 10, Fig. 304) declined from 2002-07 and changed little to 2010 before more than doubling to 2012.

The spatial distribution of the fishery has changed considerably since 2007 (Fig. 305). There has been an increase and broader distribution of fishing effort in all management areas in recent years. Temporally, the 2012 fishery was especially early relative to recent years (Fig. 306) and all other Divisions in the Newfoundland and Labrador snow crab fishery. About 35% of the total seasonal effort was expended in the first week of April, with the fishery near completed by mid-May (i.e. week 6).

Biomass

Catch per Unit Effort increased by different degrees in all CMAs in 2012 (Figs. 307-308). Similar to the offshore, the spatial extent of the fishery is positively related to CPUE in this Division (Fig. 309), which we interpret to reflect an opportunistic fishery that increases or decreases in scale dependent upon catch rates. The rapidly increasing CPUE in recent years has been associated with a rapid expansion in area fished. Conversely, the substantial decline in area fished from 2002-07 was associated with declining catch rates.

Commercial logbook CPUE throughout the season in 2012 was higher in the early and late portions of the season relative to the previous four years (Fig. 310). In terms of cumulative removals, the high early season CPUE in week one was associated with nearly half of the seasonal removals (Fig. 310). The late season increase in CPUE (i.e. weeks 7-11) was associated with only minimal removals. Most of the crab was captured quickly, with high catch rates, in 2012. The exploitable biomass, as indicated by the post-season trap survey, fluctuated at a low level from 2006 to 2010 but tripled in 2011 and changed little in 2012 (Fig. 311).

Production

Recruitment

Recruitment has recently increased and is expected to remain strong in 2013, but short-term (2-3 years) prospects are unfavourable. The post-season trap survey pre-recruit biomass index increased substantially in 2009 and changed little until it decreased substantially in 2012 (Fig. 312). The CPS trap survey catch rates of new-shelled legal-sized crabs increased substantially from about 3 kg/trap in 2009 to 8 kg/trap in 2011 and was unchanged in 2012 (Fig. 313). This increase has occurred across the entire size spectrum of legal-sized crabs (Fig. 314). However, with an elongated left tail in the distribution in 2012 there is a strong suggestion that the recruitment pulse contributing to the increased biomass has now all but fully entered into legal-size, inferring reduced short-term prospects. Nonetheless, despite a reduced

abundance, a high proportion of pre-recruit-sized crabs remained new-shelled in 2012 (Fig. 315) which suggests some contribution to the exploitable biomass is yet to come. Longer-term recruitment prospects are uncertain.

Mortality

Exploitation

The post-season trap survey-based exploitation rate index decreased sharply in 2012 (Fig. 316). This overall decrease reflects a decrease or no change in the level of exploitation in all management areas in 2012. Maintaining the current level of fishery removals would likely result in little change in the exploitation rate in 2013.

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. Data are insufficient to estimate a pre-recruit fishing mortality rate index.

Spatial variability: Trends by CMA

CMA 12C + BSG (Bay St. George)

Fishery CPUE increased from 4 kg/trap in 2010 to 10 kg/trap in 2012 (Fig. 308) coincident with an increase in landings from 50 to 180 t (Fig. 317). Recent effort levels have remained low relative to the early 2000s (Fig. 317). A large increase in recruitment into the exploitable biomass occurred in 2011 as seen by a four-fold increase in new-shelled legal-size catch rates in the CPS trap survey (Fig. 318). Overall, survey catch rates were unchanged in 2012 as the proportion of old-shelled crabs in the catch increased for the first time since 2004, which was associated with a decrease in proportion of new-shelled crabs in the catch. Virtually all of the recent recruitment pulse fueling the recently increased exploitable biomass has now achieved legal size, evident in both large-meshed (Fig. 319) and small-meshed (Fig. 320) size frequency distributions in the CPS survey. Accordingly, short-term recruitment prospects are not favourable and the fishery is likely to be dependent upon the contribution from the recent recruitment pulse for the foreseeable future.

CMA 12D (Port aux Port Bay)

Fishery CPUE has been highly variable in recent years (Fig. 308), but the 2012 increase is consistent with the broader scale trends occurring throughout Division 4R inshore. Landings have increased from 6 t in 2009 to 50 t in 2012, likely reflecting an increased biomass (Fig. 321). However, there are no fishery-independent data available upon which to assess stock status or recruitment prospects.

CMA 12E (Outer Bay of Islands)

Commercial CPUE increased in 2012 for the first time in five years (Fig. 308). It had been at a very low level of about 2 kg/ trap from 2009-11 but increased to 6 kg/trap in 2012. Landings increased from 13 t in 2010 to 50 t in 2012, when the TAC was taken for the first time since 2004 (Fig. 322). A large increase in recruitment into the exploitable biomass occurred in 2011, evident by a sharp spike in catch rates of new-shelled legal-sized crabs in the CPS survey (Fig. 323). However, the fishery appears to still be heavily dependent upon immediate recruitment as there was no associated increase in old-shelled legal-sized crabs in 2012 (Fig. 323). The catch rate of new-shelled legal-sized crabs decreased by about 50% in the 2012 survey, reflecting a general decrease in all sizes of sub-legal and legal-sized crabs (Fig. 324). It is unclear if this decrease reflects the true status of the stock, as it is inconsistent with adjacent management areas, but caution appears warranted looking forward to 2013.

CMA 12F + BOI (Bay of Islands)

Commercial CPUE increased in 2012 for the first time in five years (Fig. 308). It had been at a very low level of about 2 kg/ trap from 2009-11 but increased to 8 kg/trap in 2012. Meanwhile, landings increased from 60 t in 2009 to 110 t in 2012 (Fig. 325). The increasing removals had been associated with increased effort from 2009-2011, but a sharp decrease in effort occurred in 2012. A large increase in recruitment into the exploitable biomass occurred in 2010-11 as seen by a large increase in new-shelled legal-size catch rates in the CPS trap survey (Fig. 326). Overall, survey catch rates decreased slightly in 2012. The fishery appears to still be heavily dependent upon immediate recruitment with virtually no old-shelled crabs in the catch (Fig. 327). Small-mesh trap survey data would suggest there is still more recruitment to come over the next couple of years, with three successive years of relatively high signals of adolescent pre-recruit-sized crabs in the size frequency distributions (Fig. 328).

CMA 12G (Bonne Bay)

Fishery CPUE plummeted from 2003-08 (Fig. 308), prompting a voluntary fishing moratorium in 2009. The fishery re-opened in 2011, with high catch rates experienced in the past two years. Landings have been maintained at 100t in the past two years while effort has been at a historical low for years when fishing has occurred (Fig. 329). The CPS trap survey indicates that catch rates of legal-sized new-shelled crabs increased greatly from 2007-12 (Fig. 330) and the exploitable biomass is at its highest level in the nine year survey time series. However, virtually all of the recent recruitment pulse forming the basis of recently increased exploitable biomass has now achieved legal size, evident in both large-meshed (Fig. 331) and small-meshed (Fig. 332) size frequency distributions in the CPS survey. Accordingly, short-term recruitment prospects are not favourable and the fishery will likely be dependent upon the contribution from the recent recruitment pulse for the foreseeable future.

CMA 12H (Northern Peninsula)

Fishery CPUE has increased from 1 kg/trap in 2003 to 6 kg/trap in 2012 (Fig. 308), and the 40-50 t of landings taken during the past two years are the highest levels achieved since 2002 (Fig. 333), likely reflecting an increased exploitable biomass. There are no fishery-independent data available upon which to assess stock status or recruitment prospects but the recent improvements are consistent with broad-scale trends occurring throughout Div. 4R inshore and management area 13 to the north.

REFERENCES CITED

- Chabot, D., Sainte-Marie, B., Brandi, K., and Hanson, J.M., 2008. Atlantic cod and snow crab predator-prey size relationship in the Gulf of St. Lawrence, Canada. *Mar. Ecol. Prog. Ser.* 363: 227-240.
- Colbourne, E., J. Craig, C. Fitzpatrick, D. Senciall, P. Stead and W. Bailey. 2013. An [Assessment of the Physical Oceanographic Environment on the Newfoundland and Labrador Shelf during 2012](#). *Can. Sci. Advis. Sec. Res. Doc.* 2013/052. v + 35p.
- Dawe, E. G., J. M. Hoenig, and X. Xu. 1993. Change-in-ratio and index-removal methods for population assessment and their application to snow crab (*Chionoecetes opilio*). *Can. J. Fish. Aquat. Sci.* 50: 1467-1476.
- Dawe, E.G., Taylor, D.M., Veitch, P.J., Drew, H.J., Beck, P.C., and O'Keefe, P.G. 1997. [Status of Newfoundland and Labrador snow crab in 1996](#). *Can. Sci. Advis. Sec. Res. Doc.* 97/07. 30 p.

-
- Dawe, E. G. 2002. Trends in Prevalence of Bitter Crab Disease Caused by Hematodinium sp. in Snow Crab (*Chionoecetes opilio*) throughout the Newfoundland and Labrador Continental Shelf. pp. 385-400 In: Crabs in Cold Water Regions: Biology, Management, and Economics. Edited by A.J. Paul, E.G., Dawe, R. Elner, G.S. Jamieson, G.H. Kruse, R.S. Otto, B. Sainte-Marie, T.C. Shirley, and D. Woodby University of Alaska Sea Grant, AK-SG-02-01, Fairbanks, 786 p.
- Dawe, E.G., and E.B. Colbourne. 2002. Distribution and demography of snow crab (*Chionoecetes opilio*) males on the Newfoundland and Labrador shelf. pp. 577-594 In: Crabs in Cold Water Regions: Biology, Management, and Economics. Edited by A.J. Paul, E.G. Dawe, R. Elner, G.S. Jamieson, G.H. Kruse, R.S. Otto, B. Sainte-Marie, T.C. Shirley, and D. Woodby University of Alaska Sea Grant, AK-SG-02-01, Fairbanks, 876 p.
- Dawe, E.G., H.J. Drew, P.J. Veitch, R. Turpin, E. Seward, P.C. Beck 2003. [An Assessment of Newfoundland and Labrador Snow Crab in 2002](#). Can. Sci. Advis. Sec. Res. Doc. 2003/025, 67p.
- Dawe, E.G., D. Orr, D. Parsons, D. Stansbury, D.M. Taylor, H.J. Drew, P.J. Veitch, P.G. O'Keefe, E. Seward, D. Ings, A. Pardy, K. Skanes and P.C. Beck. 2004. [An Assessment of Newfoundland and Labrador Snow Crab in 2003](#). Can. Sci. Advis. Sec. Res. Doc. 2004/024, 110p.
- Dawe, E.G., D.M. Taylor, D. Stansbury, H.J. Drew, A. Pardy, P.J. Veitch, E. Hynick, P.G. O'Keefe, P.C. Beck, D. Mullowney and K. Skanes. 2005. [An Assessment of Newfoundland and Labrador Snow Crab in 2004](#). Can. Sci. Advis. Sec. Res. Doc. 2005/013, 114 p.
- Dawe, E.G., D. Mullowney, D. Stansbury, D. G. Parsons, D.M. Taylor, H.J. Drew, P. J. Veitch, E. Hynick, P.G. O'Keefe and P.C. Beck. 2006. [An Assessment of Newfoundland and Labrador Snow Crab in 2005](#). Can. Sci. Advis. Sec. Res. Doc. 2006/031, 129 p.
- Dawe, E. G., D. G. Parsons, and E. B. Colbourne. 2008. Relationships of sea ice extent and bottom water temperature with abundance of snow crab (*Chionoecetes opilio*) on the Newfoundland - Labrador Shelf. ICES CM 2008:B02, 18 p.
- Dawe, E. G., S. J. Walsh and E. M Hynick. 2010a. Capture efficiency of a multi-species survey trawl for Snow Crab (*Chionoecetes opilio*) in the Newfoundland region. Fish. Res. 101: 70-79.
- Dawe, E.G., D.R. Mullowney, E.B. Colbourne, G. Han, J.F. Morado, and R. Cawthorn. 2010b. Relationship of Oceanographic Variability with Distribution and Prevalence of Bitter Crab Syndrome in Snow Crab (*Chionoecetes opilio*) on the Newfoundland-Labrador Shelf. In: G.H. Kruse, G.L. Eckert, R.J. Foy, R.N. Lipcius, B. Sainte-Marie, D.L. Stram, and D. Woodby (eds.), Biology and Management of Exploited Crab Populations under Climate Change. Alaska Sea Grant, University of Alaska Fairbanks. doi:10.4027/bmecipcc.2010.06
- Dawe, E., D. Mullowney, D. Stansbury, K. Skanes, E. Hynick, D. Fiander, P. Veitch, E. Colbourne, P. O'Keefe, and D. Maddock Parsons 2011. [An Assessment of Newfoundland and Labrador Snow Crab in 2009](#). Can. Sci. Advis. Sec. Res. Doc. 2011/073, 189 p.
- Dawe, E.G., Mullowney, D.R., Moriyasu, M., and Wade, E., 2012a. Effects of temperature on size-at-terminal molt and molting frequency in snow crab (*Chionectes opilio*) from two Canadian Atlantic ecosystems. Mar. Ecol. Prog. Ser 469: 279-296.
- Dawe, E.G., Koen-Alonso, M., Chabot, D., Stansbury, D., and Mullowney, D., 2012b. Trophic interactions between key predatory fishes and crustaceans: comparison of two Northwest Atlantic systems during a period of ecosystem change Mar. Ecol. Prog. Ser 469: 233-248.
-

-
- Dufour, R., D. Bernier, J.-C. Brêthes 1997. Optimization of meat yield and mortality during snow crab (*Chionoecetes opilio* O. Fabricius) fishing operations in Eastern Canada. Can. Tech. rep. fish. aquat. Sci. 2152 : viii + 30p.
- Hoening, J.M., E.G. Dawe, and P.G. O'Keefe. 1994. Molt indicators and growth per molt for male snow crabs (*Chionoecetes opilio*). J. Crust. Biol. 14(2): 273-279.
- Marcello, L.A., Mueter, F., Dawe, E.G., and Moriyasu, M., 2012. Effects of temperature and gadid predation on snow crab recruitment: Comparisons between the Bering Sea and Atlantic Canada. Mar. Ecol. Prog. Ser. 469: 249-216
- Miller, R.J. 1977. Resource Underutilization in a Spider Crab Industry. Fisheries, Vol. 2. No. 3 : 9–13.
- Mullowney, D.R., and E.G. Dawe, 2009. Development of performance indices for the Newfoundland & Labrador snow crab (*Chionoecetes opilio*) fishery using data from a vessel monitoring system. Fish. Res. 100: 248-254.
- Mullowney, D.R., Dawe, E.G., Morado, J.F., and Cawthorn, R.J. 2011. Sources of variability in prevalence and distribution of bitter crab disease in snow crab (*Chionoecetes opilio*) along the northeast coast of Newfoundland. ICES J. Mar. Sci. 68: 463-471.
- Mullowney, D., Dawe, E., Skanes, K., Hynick, E., Coffey, W., O'Keefe, P., Fiander, D., Stansbury, D., Colbourne, E., and Maddock Parsons, D., 2012a. [An Assessment of Newfoundland and Labrador Snow Crab \(*Chionoecetes opilio*\) in 2010](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2012/045. iii + 178 p.
- Mullowney, D.R.J., Morris, C.J., Dawe, E.G., and Skanes, K.R. 2012b. Impacts of a bottom trawling exclusion zone on Snow Crab abundance and fish harvester behavior in the Labrador Sea, Canada. J. Mar. Policy 36: 567-575.
- Mullowney, D., Dawe, E., Skanes, K., Hynick, E., Coffey, W., O'Keefe, P., Fiander, D., Stansbury, D., Colbourne, E., and Maddock Parsons, D. 2013. [An assessment of Newfoundland and Labrador Snow Crab \(*Chionoecetes opilio*\) in 2011](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2012/160. ii + 206 p.
- Puebla, O., J-M. Sevigny, B. Sainte-Marie, J-C. Brethes, A. Burmeister, E. G. Dawe, and M. Moriyasu. 2008. Population genetic structure of the snow crab (*Chionoecetes opilio*) at the Northwest Atlantic scale. Can. J. Fish. Aquat. Sci. 65: 425-436.
- Smith, S.J., and G.D. Somerton. 1981. STRAP: A user-oriented computer analysis system for groundfish research trawl survey data. Can. Tech. Rep. Fish. Aquat. Sci. 1030: 66 p.

Table 1: Annual Overall (Divisions 2HJ3KLNOP4R) TAC and Landings, by year.

YEAR	TAC(t)	LANDINGS(t)
1995	27,875	32,334
1996	34,864	37,967
1997	42,015	45,726
1998	49,225	52,677
1999	61,806	69,131
2000	51,169	55,434
2001	52,267	56,727
2002	56,981	59,418
2003	56,250	58,362
2004	53,590	55,675
2005	49,978	43,958
2006	46,233	47,238
2007	47,663	50,207
2008	54,338	52,775
2009	54,110	53,451
2010	56,087	52,215
2011	55,559	52,948
2012	52,260	50,508

Table 2: Annual Total Allowable Catch, Landings, Effort and Catch Per Unit Effort for Division 2HJ.

YEAR	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	CPUE (kg/trap)
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	3,682	304,298	12.1
2001	3,340	3,754	426,591	8.8
2002	3,381	3,520	577,049	6.1
2003	2,265	2,510	583,721	4.3
2004	1,780	1,925	534,722	3.6
2005	1,425	1,576	297,358	5.3
2006	1,425	2,139	257,711	8.3
2007	1,570	2,523	274,239	9.2
2008	2,466	2,549	240,472	10.6
2009	2,466	2,387	298,375	8
2010	2,227	2,131	280,395	7.6
2011	2,197	1,933	371,731	5.2
2012	1,952	1,606	286,786	5.6

Table 3: Fall multi-species survey exploitable and pre- recruit biomass indices with confidence intervals and mean catch, by year, for Division 2HJ.

EXPLOITABLE CRAB IN 2HJ

YEAR	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower	
1995	3472	4806	2138	1.29
1996	6120	8262	3977	1.33
1997	10675	16366	4983	2.68
1998	12691	18249	7132	2.80
1999	6304	8396	4212	1.39
2000	3555	4525	2584	1.13
2001	3249	4078	2421	0.75
2002	852	1312	392	0.27
2003	1015	1686	343	0.32
2004	1466	2082	850	0.32
2005	2009	10750	-6733	0.63
2006	3370	11496	-4756	0.74
2007	2787	4402	1172	0.88
2008	2073	3053	1092	0.48
2009	1464	2566	361	0.46
2010	1387	2027	747	0.31
2011	889	4799	-3021	0.20
2012	1195	8033	-5643	0.26

PRE RECRUIT CRAB IN 2HJ

YEAR	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower	
1995	2031	2943	1119	0.75
1996	2965	4321	1608	0.65
1997	2992	4227	1758	0.75
1998	3392	4544	2239	0.75
1999	1156	1977	335	0.26
2000	1269	1857	681	0.40
2001	1313	3207	-581	0.30
2002	589	2883	-1705	0.19
2003	917	1311	523	0.29
2004	4803	33557	-23951	1.05
2005	1657	3655	-341	0.52
2006	2296	4944	-351	0.50
2007	1306	3042	-429	0.41
2008	1237	4714	-2240	0.29
2009	1675	11754	-8405	0.53
2010	982	4843	-2879	0.22
2011	1732	8450	-4985	0.39
2012	1826	3170	481	0.40

Table 4: Annual Total Allowable Catch, Landings, Effort and Catch Per Unit Effort for Inshore and Offshore Division 3K.

INSHORE 3K

YEAR	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	LOGBOOK CPUE (kg/trap)
1995	1,800	1,814	221,220	8.2
1996	3,250	3,127	488,594	6.4
1997	3,200	2,885	497,414	5.8
1998	2,690	2,582	452,982	5.7
1999	2,892	3,082	770,500	4
2000	2,010	2,084	434,167	4.8
2001	2,210	2,510	278,889	9
2002	2,500	2,801	345,802	8.1
2003	2,825	2,975	444,030	6.7
2004	2,770	2,879	543,208	5.3
2005	2,535	2,243	477,234	4.7
2006	2,135	2,247	345,692	6.5
2007	2,270	2,450	247,475	9.9
2008	2,770	2,777	241,478	11.5
2009	2,970	2,873	354,691	8.1
2010	2,720	2,251	401,964	5.6
2011	2,440	2,009	410,000	4.9
2012	2,120	1,893	332,105	5.7

OFFSHORE 3K

YEAR	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)
1995	9,650	10,512	750,857	-
1996	9,700	11,083	846,031	-
1997	11,100	11,911	888,881	-
1998	12,700	14,103	946,510	-
1999	14,950	17,898	1,345,714	-
2000	11,218	13,056	1,186,909	-
2001	11,218	12,519	1,251,900	-
2002	12,183	12,870	1,191,667	-
2003	12,183	12,920	1,242,308	-
2004	12,183	12,943	1,703,026	221.6
2005	9,745	5,972	853,143	196.6
2006	7,995	7,984	700,351	312.5
2007	8,930	9,215	631,164	445.3
2008	11,620	11,594	711,288	416.1
2009	12,780	12,599	1,223,204	278.7
2010	11,045	9,613	1,044,891	236.0
2011	9,056	8,219	1,110,676	196.2
2012	6,792	5,988	843,380	183.5

Table 5: Fall multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch, by year, for Division 3K.

EXPLOITABLE CRAB IN 3K

YEAR	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower	
1995	11676	14534	8817	2.84
1996	20234	24352	16116	4.92
1997	18712	22724	14700	4.55
1998	18918	23156	14679	4.60
1999	8674	11366	5982	2.11
2000	9976	12668	7283	2.59
2001	11907	16504	7309	2.90
2002	9042	11742	6342	2.20
2003	3644	4603	2685	0.89
2004	5550	7061	4039	1.35
2005	6969	8897	5041	1.69
2006	10939	13469	8409	2.78
2007	16887	22236	11538	4.11
2008	16157	21399	10914	3.93
2009	7928	10301	5554	1.93
2010	6712	8535	4888	1.63
2011	5863	8207	3518	1.43
2012	5581	6943	4218	1.36

PRE-RECRUIT CRAB IN 3K

YEAR	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower	
1995	7424	9924	4925	1.81
1996	10632	14312	6952	2.59
1997	13405	17865	8945	3.26
1998	9992	13912	6071	2.43
1999	3487	4871	2104	0.85
2000	9608	13251	5965	2.49
2001	6684	8937	4432	1.63
2002	5178	7343	3012	1.26
2003	2461	4047	875	0.60
2004	5378	8989	1767	1.31
2005	5765	7867	3664	1.40
2006	9971	15093	4848	2.53
2007	5256	7199	3313	1.28
2008	8220	12306	4134	2.00
2009	5684	7796	3573	1.38
2010	4030	5839	2221	0.98
2011	4715	7409	2020	1.15
2012	3522	5559	1484	0.86

Table 6: Annual Total Allowable Catch, Landings, Effort and Catch Per Unit Effort for Inshore and Offshore Divisions 3LNO.

INSHORE 3L

YEAR	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	LOGBOOK CPUE (kg/trap)
1995	6,475	6,795	471,875	14.4
1996	7,675	7,922	665,714	11.9
1997	5,850	6,398	627,255	10.2
1998	7,225	6,882	583,220	11.8
1999	5,350	5,453	482,566	11.3
2000	4,633	4,731	407,845	11.6
2001	5,615	5,543	518,037	10.7
2002	6,540	6,524	582,500	11.2
2003	6,774	6,814	841,235	8.1
2004	6,255	6,421	823,205	7.8
2005	6,045	6,114	745,610	8.2
2006	6,095	6,229	629,192	9.9
2007	6,105	6,485	584,234	11.1
2008	7,033	6,823	554,715	12.3
2009	7,210	7,091	662,710	10.7
2010	7,449	7,283	687,075	10.6
2011	7,122	7,069	648,532	10.9
2012	7,407	7,370	534,058	13.8

OFFSHORE 3LNO

YEAR	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)
1995	5,175	7,212	389,838	-
1996	7,100	8,494	534,214	-
1997	13,075	14,293	898,931	-
1998	13,250	15,111	873,468	-
1999	24,275	27,329	1,518,278	-
2000	20,502	22,083	1,150,156	-
2001	20,465	22,630	1,197,354	-
2002	22,333	23,528	1,258,182	-
2003	23,703	24,828	1,451,930	-
2004	23,703	24,676	1,701,793	479.6
2005	23,703	23,557	1,682,643	454.8
2006	23,703	24,514	1,776,377	433.0
2007	23,703	24,405	2,033,750	426.1
2008	24,148	23,375	2,105,856	323.2
2009	21,769	21,942	1,924,737	334.3
2010	24,195	24,136	1,736,403	392.0
2011	26,100	25,846	1,900,441	413.4
2012	26490	26,151	1,614,259	499.7

Table 7: Fall multi-species survey exploitable and pre- recruit biomass indices with confidence intervals and mean catch by year for Divisions 3LNO. (The multi-species survey was incomplete in 2004 and 2006)

EXPLOITABLE CRAB IN 3LNO

YEAR	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower	
1995	31839	40594	23083	3.09
1996	37461	45018	29903	3.68
1997	24527	30227	18827	2.39
1998	34288	42552	26024	3.33
1999	20822	25163	16480	2.04
2000	15507	19841	11172	1.53
2001	24501	31053	17950	2.38
2002	19304	25312	13297	1.88
2003	15363	19789	10937	1.50
2004	9638	15675	3601	1.04
2005	15725	27161	4288	1.53
2006	5027	6541	3513	0.49
2007	9711	14600	4822	0.94
2008	14991	19360	10622	1.46
2009	22397	31968	12826	2.18
2010	17866	27044	8687	1.74
2011	14882	19278	10485	1.45
2012	16013	22959	9068	1.56

PRE -RECRUIT CRAB IN 3LNO

YEAR	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower	
1995	17719	23358	12081	1.72
1996	26733	36837	16629	2.62
1997	16266	61740	-29207	1.58
1998	21015	40946	1084	2.04
1999	10940	15694	6186	1.07
2000	10416	13969	6863	1.03
2001	10159	13405	6913	0.99
2002	5615	8519	2711	0.55
2003	8234	14106	2362	0.80
2004	3831	9389	-1727	0.41
2005	4582	7095	2069	0.45
2006	2637	3865	1409	0.26
2007	8072	11083	5062	0.78
2008	16457	23298	9615	1.60
2009	19054	26373	11735	1.85
2010	17597	27346	7848	1.72
2011	8809	42479	-24861	0.86
2012	7179	12096	2263	0.70

Table 8: Annual Total Allowable Catch, Landings, Effort and Catch Per Unit Effort for Inshore and Offshore Subdivision 3Ps.

INSHORE 3Ps

YEAR	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	LOGBOOK CPUE (kg/trap)
1995	1,200	1,035	161,719	6.4
1996	1,350	1,309	73,955	17.7
1997	2,400	2,305	187,398	12.3
1998	2,500	3,367	333,366	10.1
1999	3,701	3,598	342,667	10.5
2000	3,300	3,501	350,100	10
2001	3,200	3,436	279,350	12.3
2002	3,200	3,280	410,000	8
2003	2,520	2,369	415,614	5.7
2004	1,630	1,302	372,000	3.5
2005	1,300	705	207,353	3.4
2006	975	781	195,250	4.0
2007	975	1,146	204,643	5.6
2008	1,128	1,426	163,908	8.7
2009	1,500	1,939	157,642	12.3
2010	1,900	2,161	154,357	14.0
2011	2,462	2,456	188,923	13.0
2012	2,542	2,521	210,083	12.0

OFFSHORE 3Ps

YEAR	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)
1995	525	894	45,846	-
1996	1,700	1,665	99,701	-
1997	2,200	2,370	117,910	-
1998	3,700	3,257	134,033	-
1999	4,298	4,307	177,975	-
2000	4,400	4,386	212,913	-
2001	4,400	4,403	271,790	-
2002	4,400	4,357	360,083	-
2003	3,565	3,750	451,807	-
2004	2,765	3,418	421,975	217.5
2005	2,800	2,468	398,065	159.7
2006	2,070	2,324	297,949	179.8
2007	2,270	2,816	361,026	200.9
2008	3,230	3,097	279,009	257.0
2009	3,780	3,620	285,039	289.5
2010	4,305	3,865	333,190	276.3
2011	4,565	4,261	439,278	260.0
2012	3,925	3,687	414,270	235.5

Table 9: Spring multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch by year for Subdivision 3Ps. (The multi-species survey was incomplete in 2006)

EXPLOITABLE CRAB IN 3Ps

YEAR	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower	
1996	4535	7943	1128	1.88
1997	1119	1691	547	0.47
1998	1476	2273	679	0.61
1999	2528	4429	626	1.05
2000	927	1390	465	0.38
2001	500	801	199	0.21
2002	427	618	236	0.18
2003	433	1167	-301	0.18
2004	211	308	114	0.09
2005	503	803	203	0.21
2006	18	74	-37	0.03
2007	246	411	81	0.10
2008	379	570	189	0.16
2009	935	1599	272	0.39
2010	790	1313	268	0.33
2011	416	675	158	0.17
2012	354	613	95	0.15

PRE-RECRUIT CRAB IN 3Ps

YEAR	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower	
1996	1839	3582	96	0.76
1997	291	522	59	0.12
1998	601	1086	116	0.25
1999	324	466	181	0.13
2000	235	443	26	0.10
2001	311	614	7	0.13
2002	309	478	140	0.13
2003	97	196	-1	0.04
2004	209	336	82	0.09
2005	437	630	244	0.18
2006	51	122	-21	0.07
2007	780	1768	-209	0.32
2008	1058	2966	-849	0.44
2009	1422	2382	462	0.59
2010	460	1038	-117	0.19
2011	194	324	63	0.08
2012	168	328	8	0.07

Table 10: Annual Total Allowable Catch, Landings, Effort and Catch Per Unit Effort for Inshore and Offshore Division 4R3Pn.

INSHORE 4R3Pn

YEAR	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	LOGBOOK CPUE (kg/trap)
1998	1,310	1,067	197,593	5.4
1999	690	988	161,967	6.1
2000	785	954	190,800	5
2001	909	1,026	190,000	5.4
2002	904	878	100,920	8.7
2003	1,050	954	117,778	8.1
2004	1,016	877	139,206	6.3
2005	1,000	511	81,111	6.3
2006	860	460	85,185	6.1
2007	750	368	85,581	3.6
2008	718	250	65,789	4.7
2009	483	199	53,784	4.1
2010	482	188	50,811	3.7
2011	615	446	94,894	4.7
2012	641	550	67,901	8.1

OFFSHORE 4R3Pn

YEAR	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)
1998	-	-	-	-
1999	645	629	149,762	-
2000	645	674	134,800	-
2001	635	649	147,500	-
2002	845	977	195,400	-
2003	845	608	168,889	-
2004	838	584	182,500	120.0
2005	845	348	108,750	115.4
2006	675	79	22,571	89.7
2007	540	194	77,600	89.7
2008	540	131	37,429	81.8
2009	418	88	31,429	74.7
2010	418	33	10,000	107.4
2011	414	149	49,667	77.5
2012	418	191	46,585	96.8

Table 11: Summer multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch by year for Divisions 4R3Pn.

EXPLOITABLE CRAB IN 4R3Pn

YEAR	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower	
2004	111	292	-70	0.19
2005	82	273	-109	0.24
2006	180	431	-72	0.30
2007	92	261	-77	0.15
2008	174	552	-205	0.29
2009	229	1099	-640	0.39
2010	80	188	-28	0.13
2011	365	820	-90	0.61
2012	175	452	-101	0.29

PRE-RECRUIT CRAB IN 4R3Pn

YEAR	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower	
2004	195	917	-527	0.33
2005	14	74	-46	0.04
2006	46	116	-24	0.08
2007	54	260	-151	0.09
2008	52	121	-17	0.09
2009	74	337	-189	0.12
2010	18	52	-16	0.03
2011	94	861	-127	0.16
2012	36	79	-8	0.06

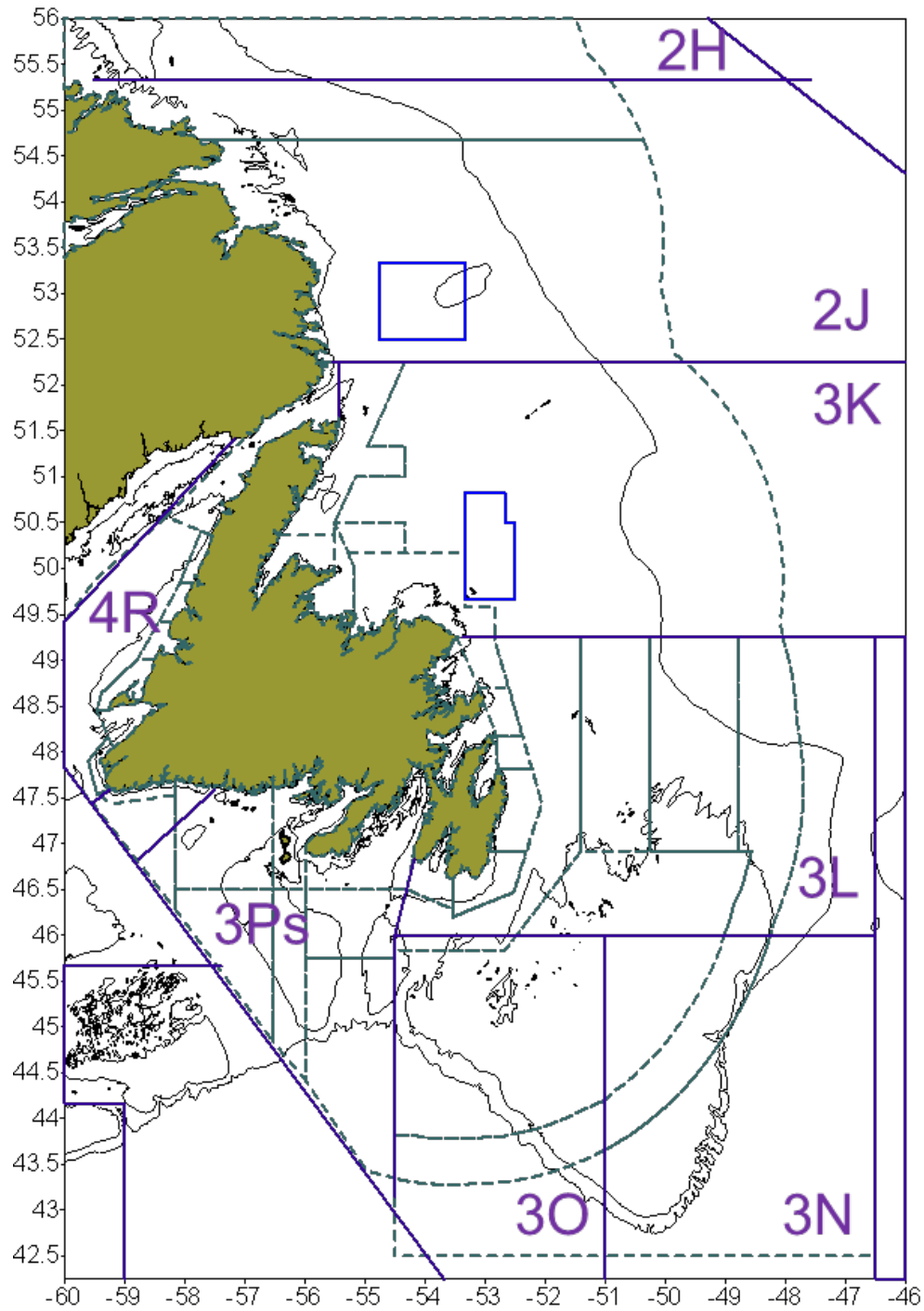


Figure 1: NAFO Divisions (purple lines), Newfoundland and Labrador Snow Crab Management Areas (green lines), trawling and gillnetting closures (blue boxes), and bathymetry of the Newfoundland and Labrador shelf (grey underlay).

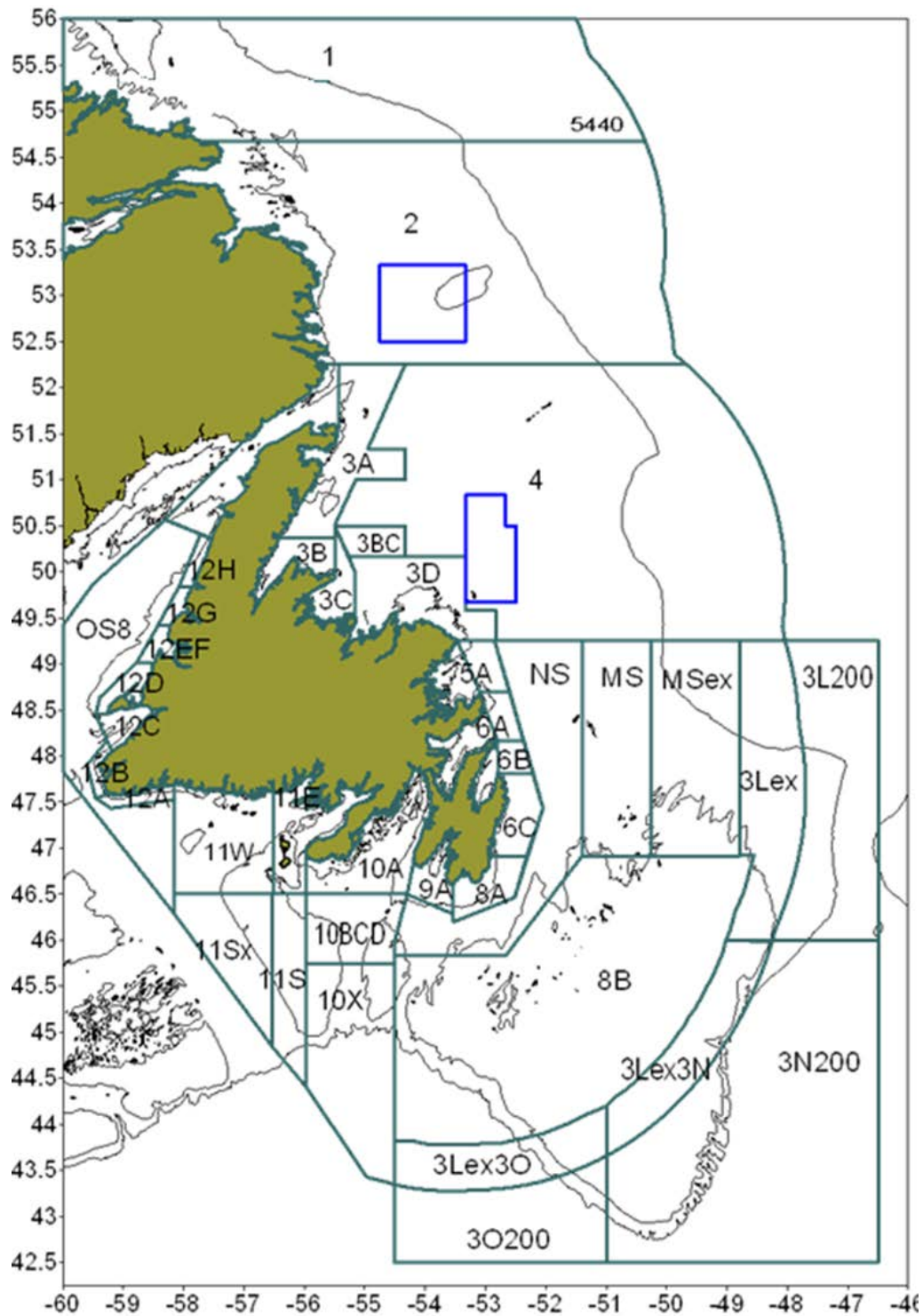


Figure 2. Newfoundland and Labrador Snow Crab Management Areas (CMAs).

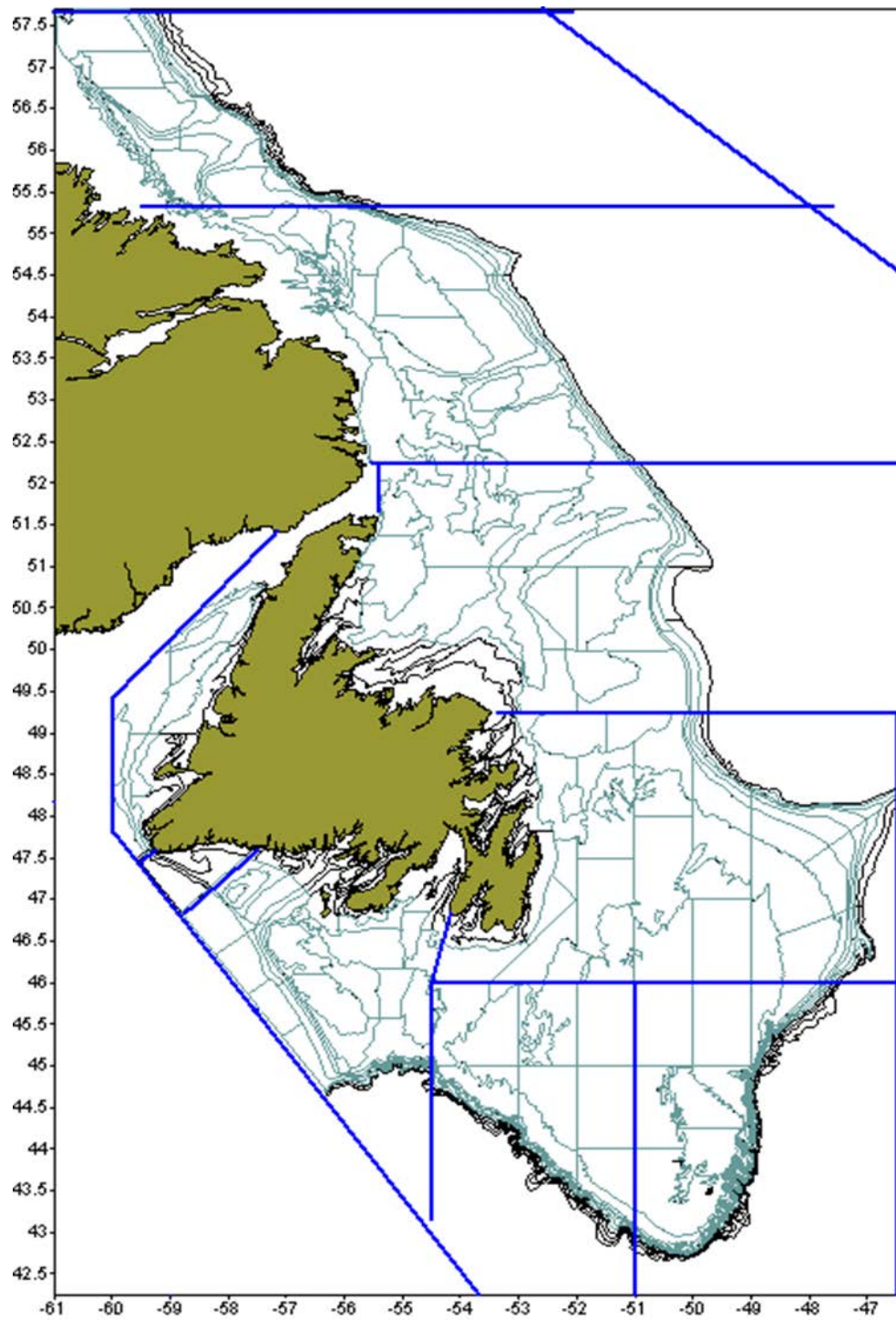


Figure 3: DFO multi-species trawl survey strata. Core strata shown in teal.

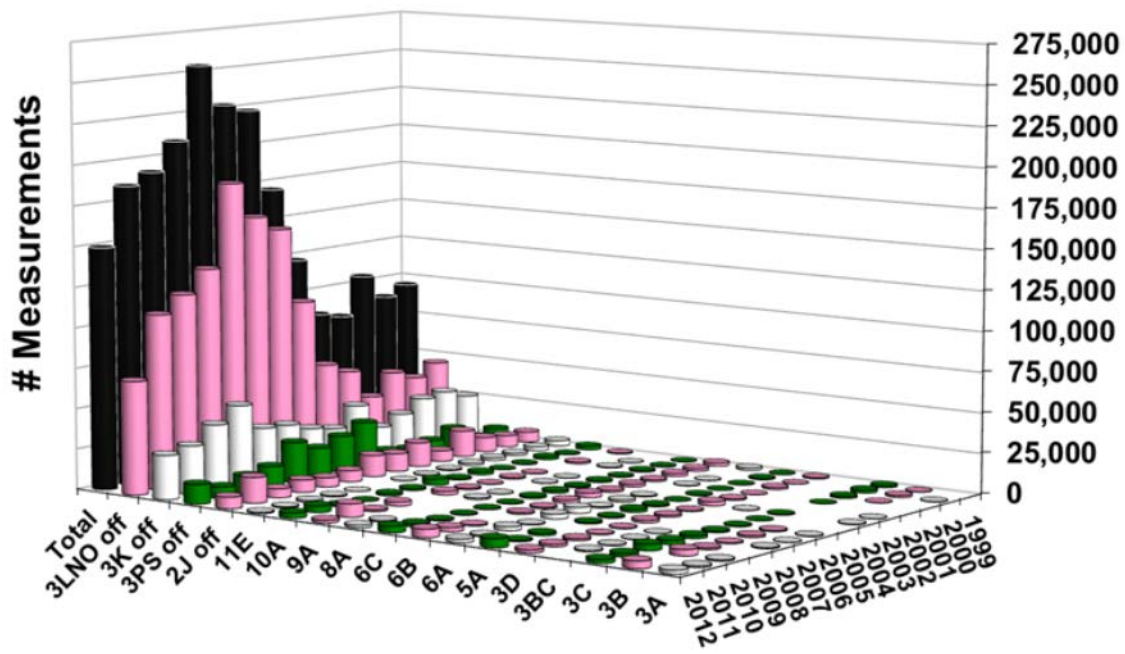


Figure 4: Observer sampling by CMA and year. Data pooled for offshore crab management areas in each Division.

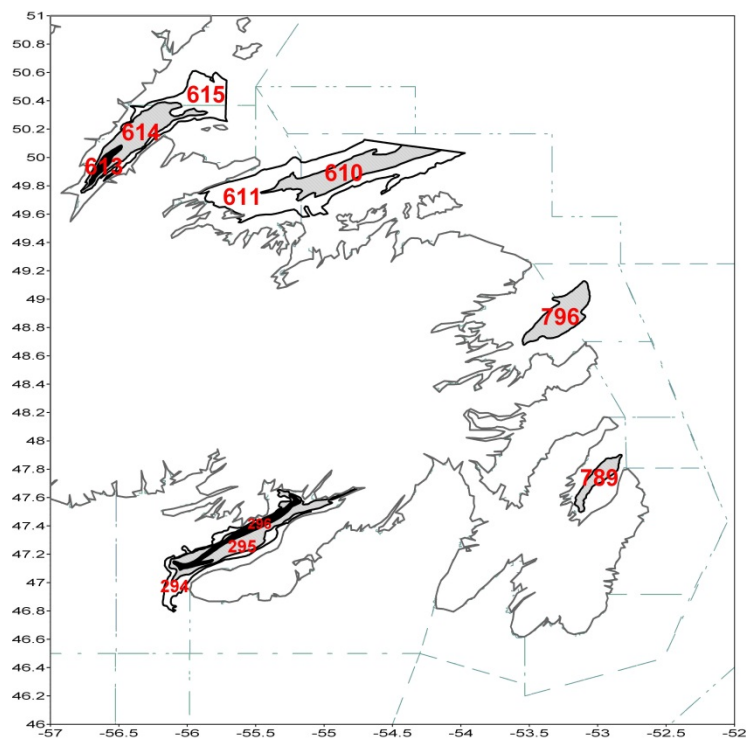


Figure 5: Strata sampled during DFO inshore trap and trawl surveys.

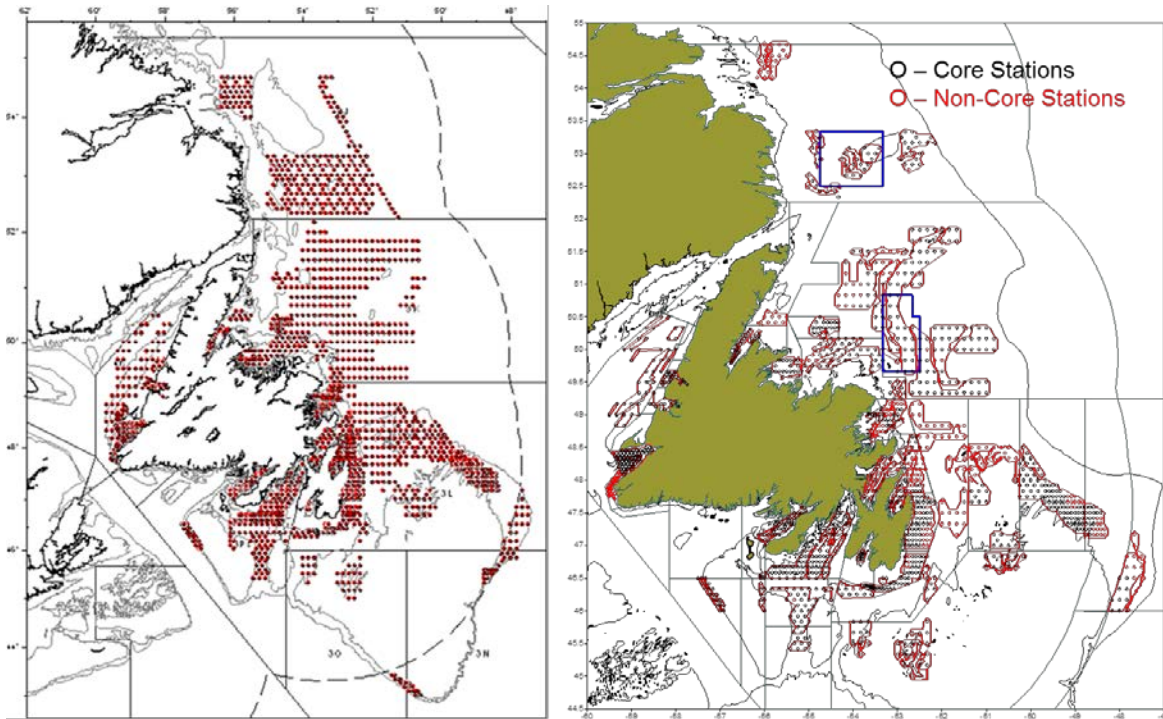


Figure 6: Industry – DFO Collaborative Post-Season trap survey design (left). Occupied, and core stations, as well as stratification scheme used for data analyses (right).

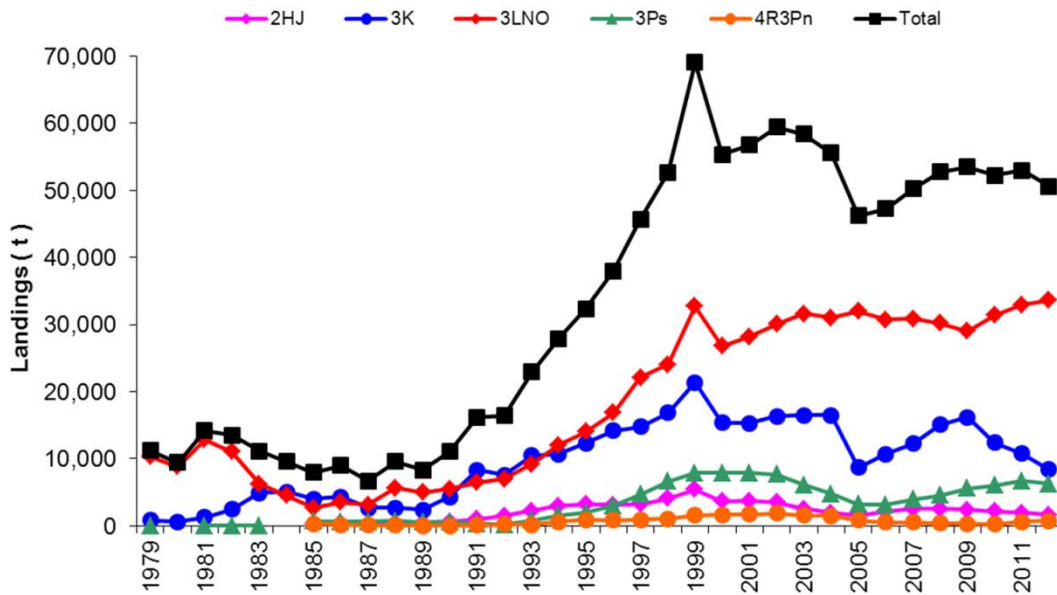


Figure 7: Trends in annual landings by NAFO Division and in total.

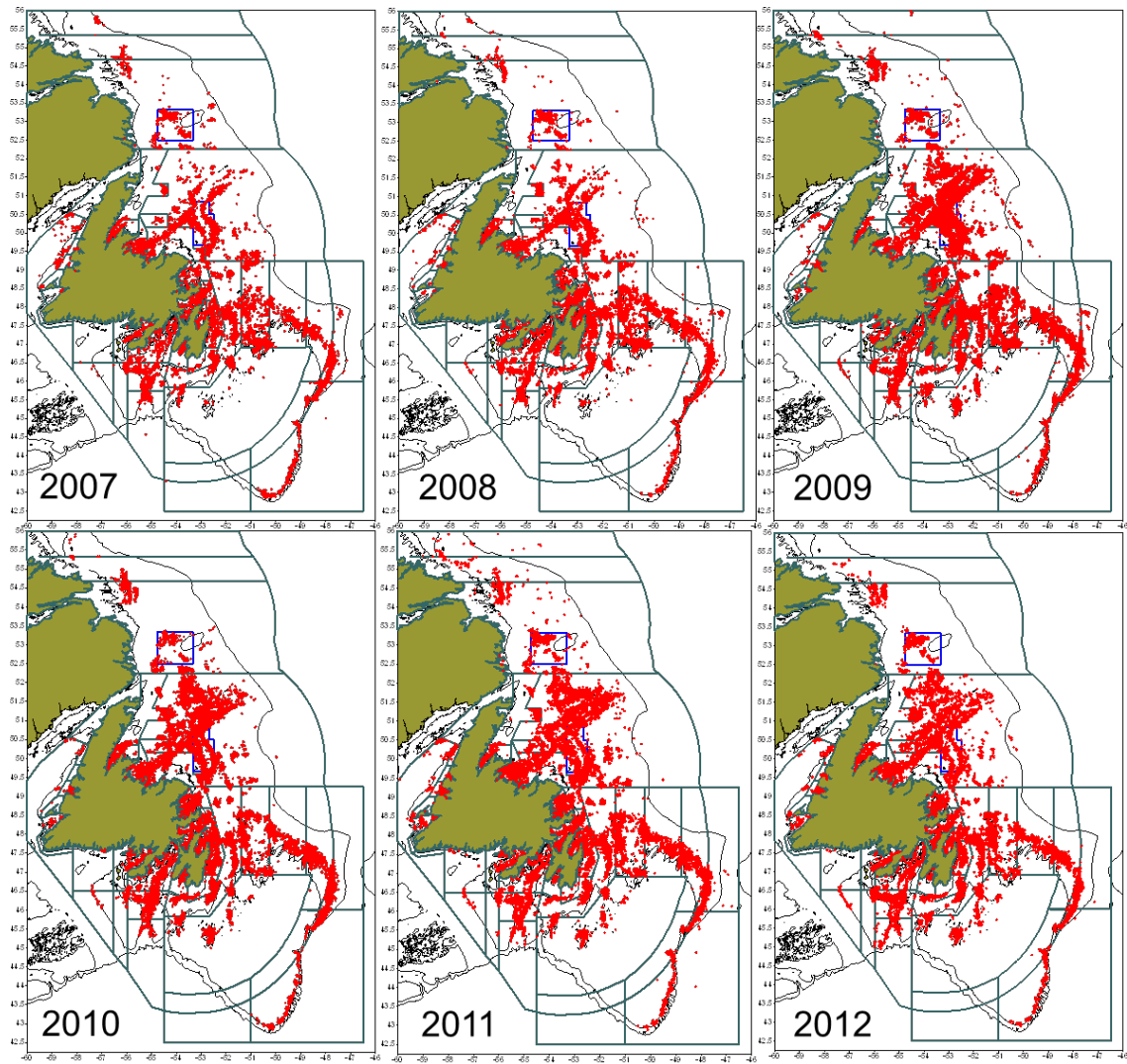


Figure 8: Distribution of logbook fishing effort from 2006-2012.

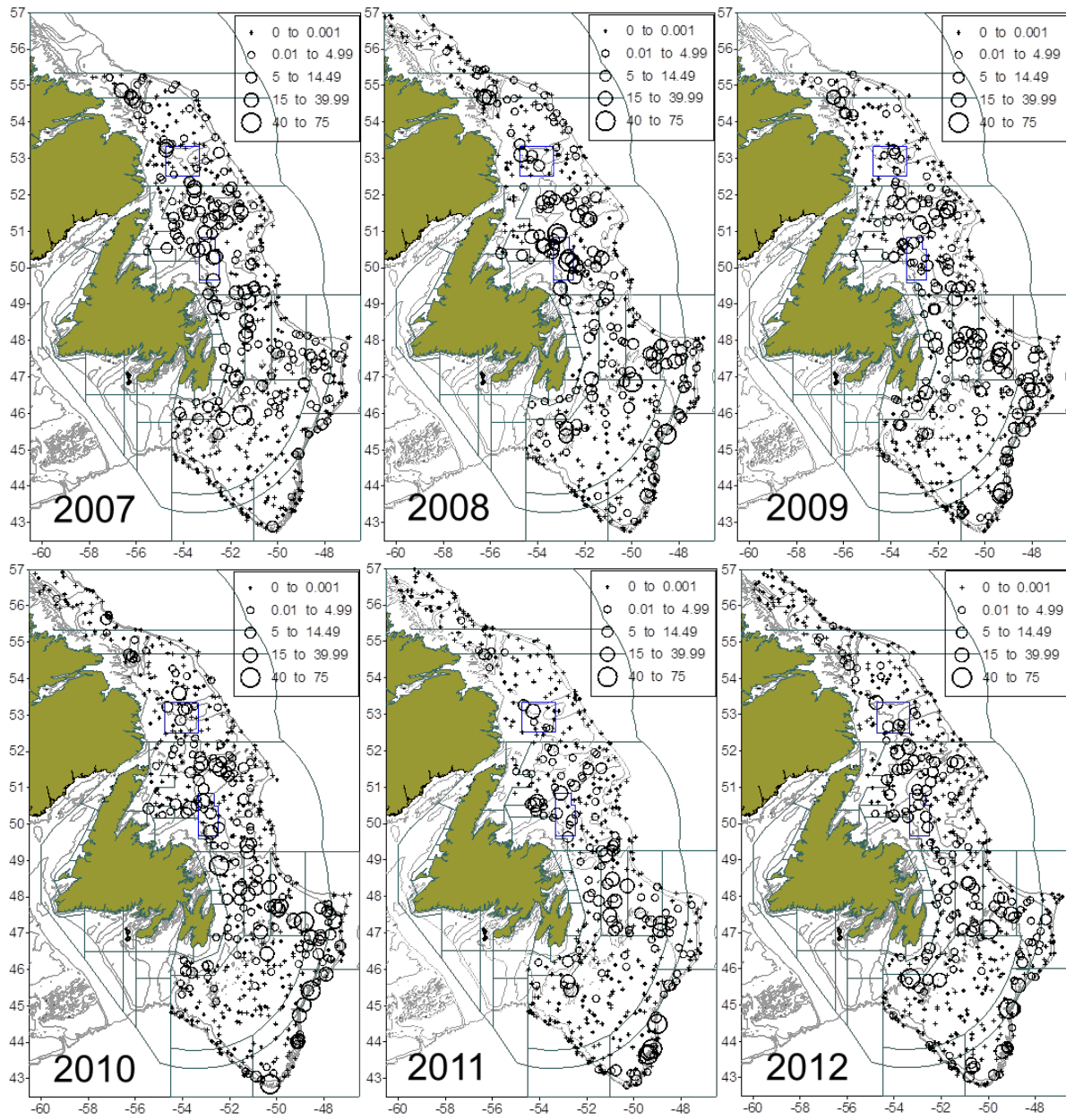


Figure 9: Distribution of exploitable males (> 94mm CW adults) from fall Div. 2HJ3KLNO bottom trawl surveys from 2007-2012.

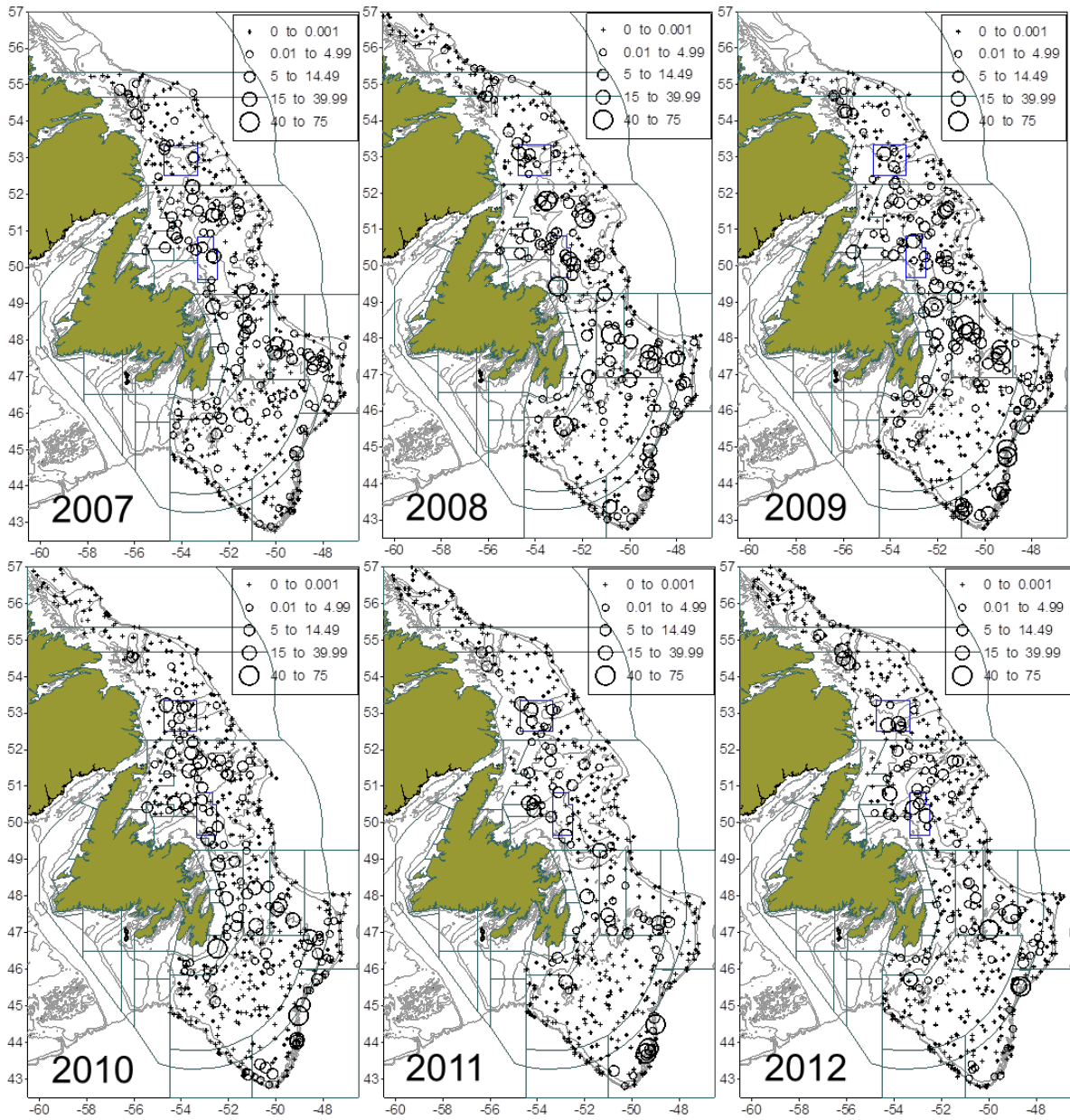


Figure 10: Distribution of pre-recruit males (> 75mm CW adolescents) from fall Div. 2HJ3KLNO bottom trawl surveys from 2007-2012.

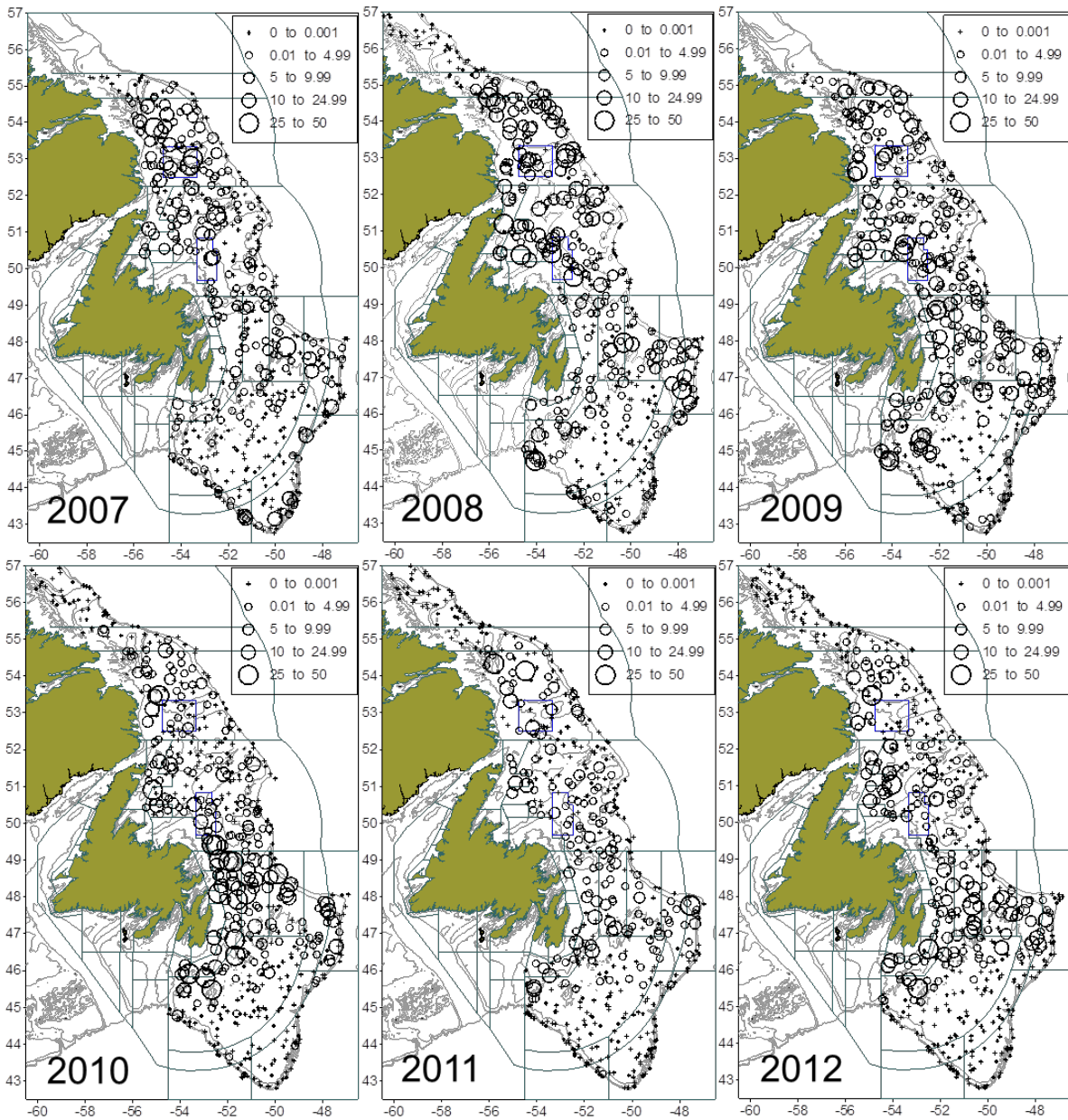


Figure 11: Distribution of small males (< 60mm CW adolescents) from fall Div. 2HJ3KLNO bottom trawl surveys from 2007-2012.

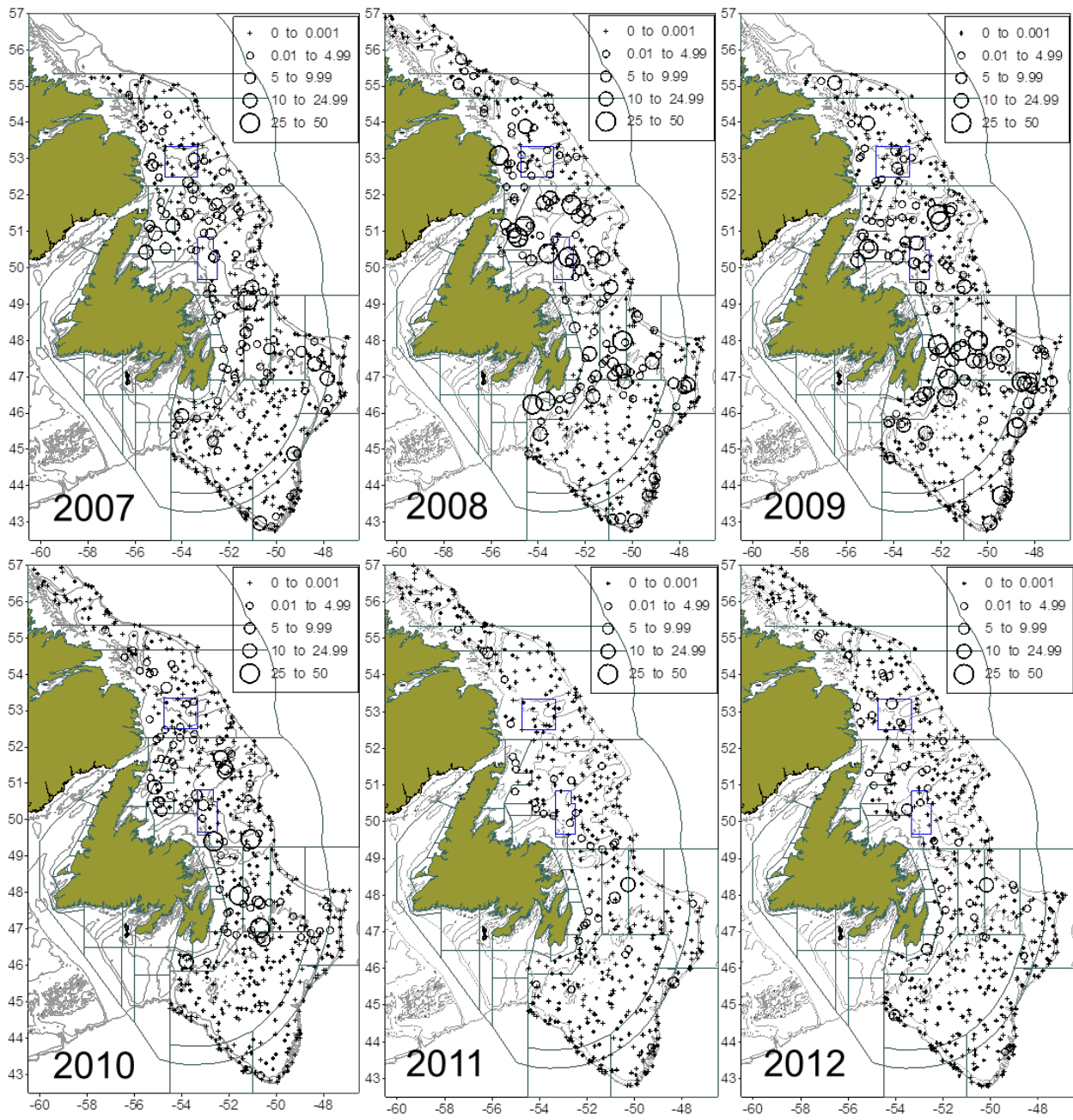


Figure 12: Distribution of mature females from fall Div. 2HJ3KLNO bottom trawl surveys from 2007-2012.

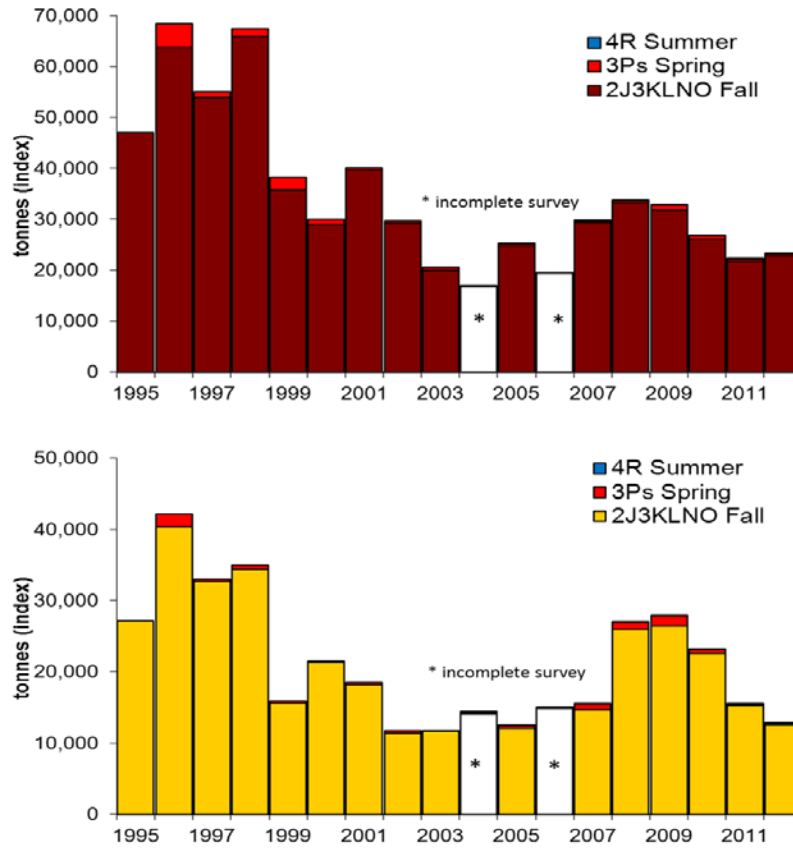


Figure 13: Trends in the trawl survey exploitable (above) and pre-recruit (below) biomass indices for Div. 2J3KLNO during fall, Subdiv. 3Ps during spring, and Div. 4R during summer. Note that season-specific indices are not additive due to differences in trawl efficiency.

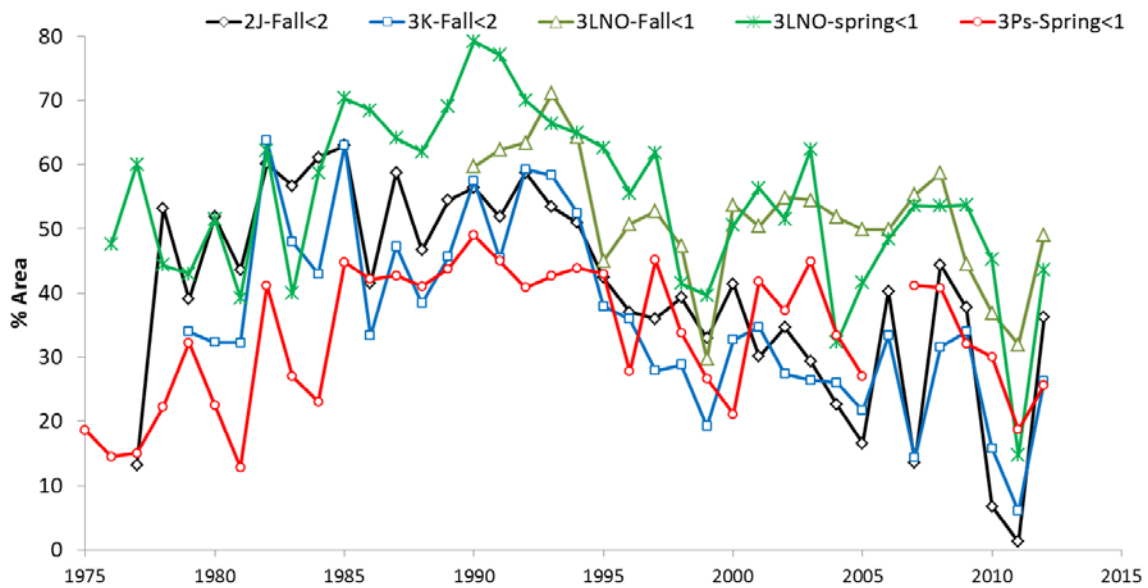


Figure 14: Snow crab thermal habitat index from fall multi-species trawl surveys.

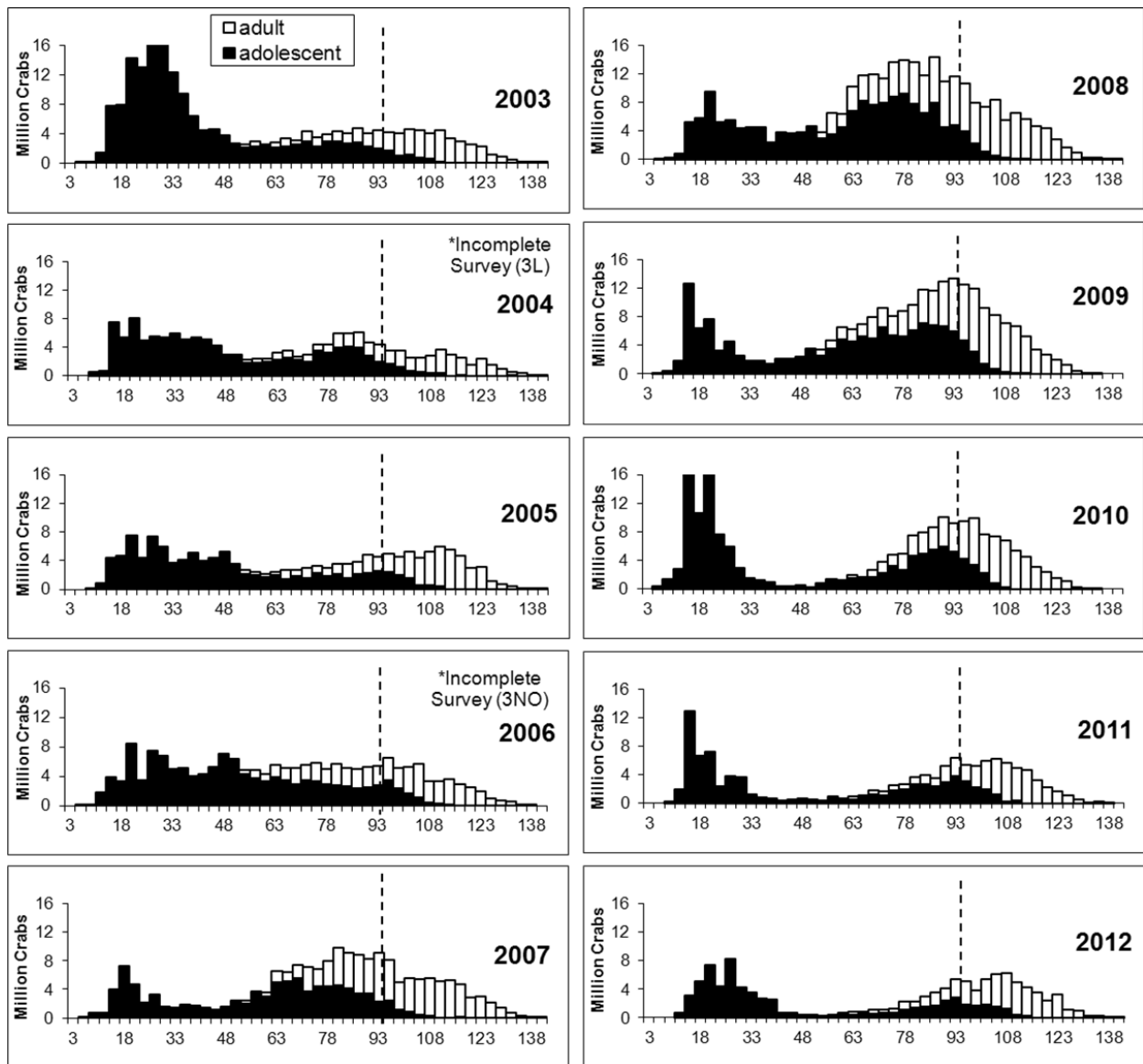


Figure 15: Annual abundance indices since 2003 by carapace width for Div. 2J3KLNO juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line.

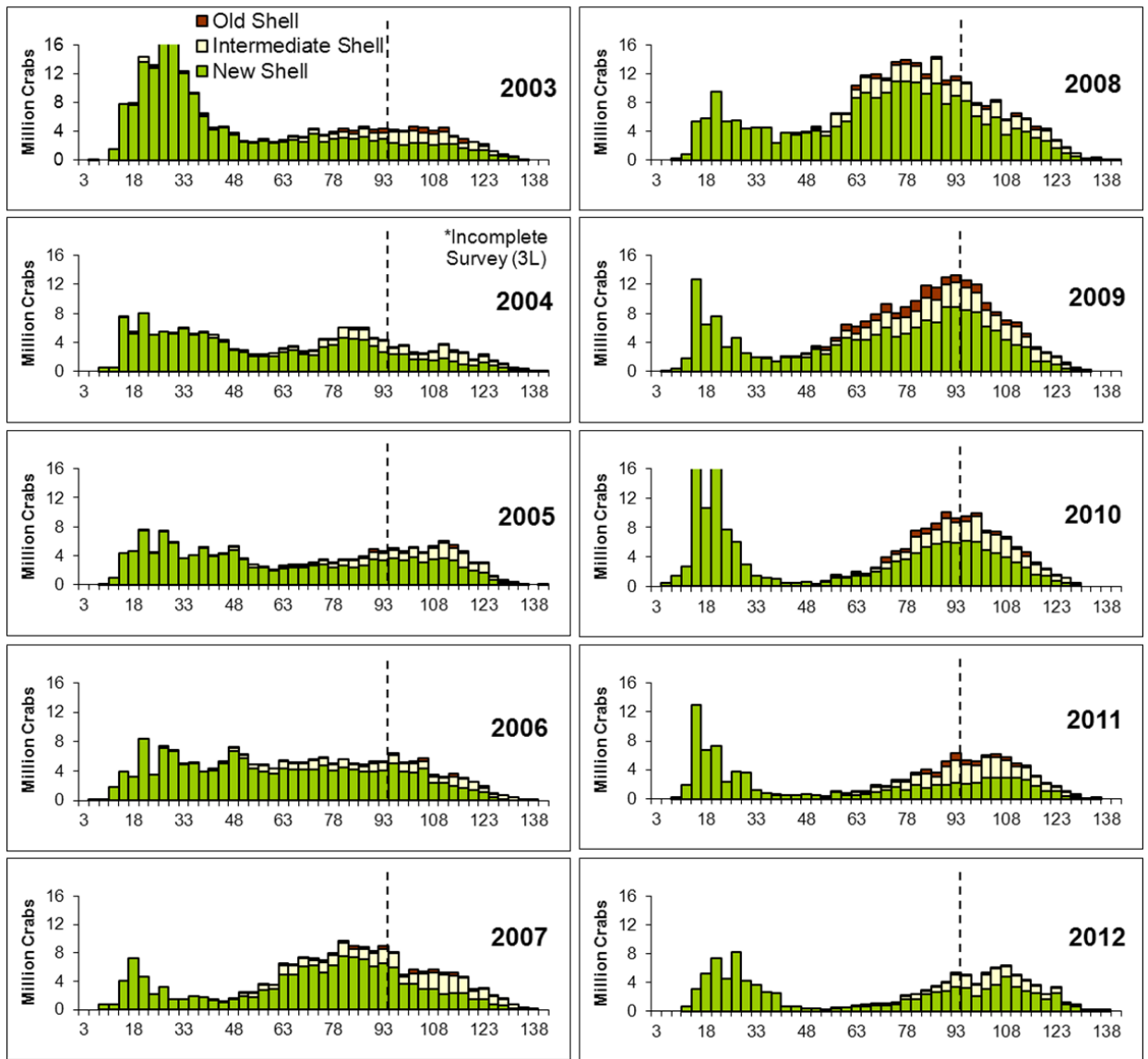


Figure 16: Annual abundance indices since 2003 by carapace width and shell condition from fall trawl surveys for Div. 2J3KLNO. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line.

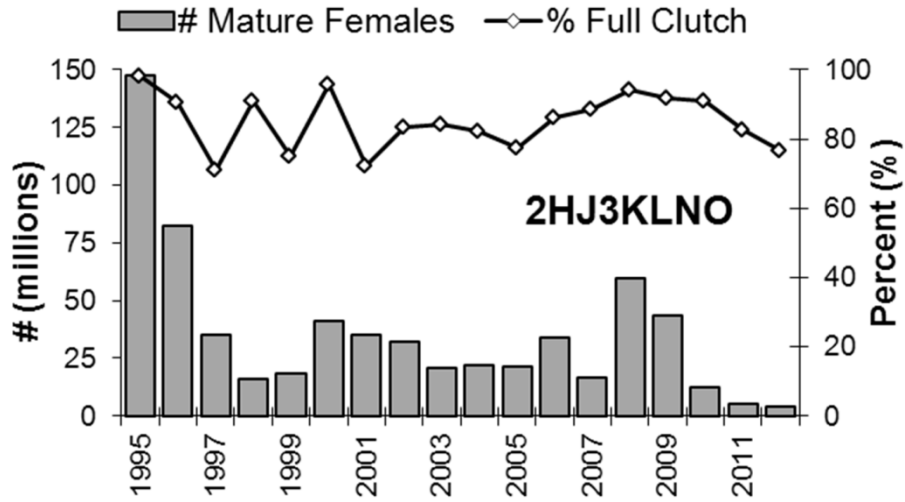


Figure 17: Trends in the mature female abundance index and percentage of mature females bearing full clutches of viable eggs in Div. 2HJ3KLNO from fall multi-species surveys.

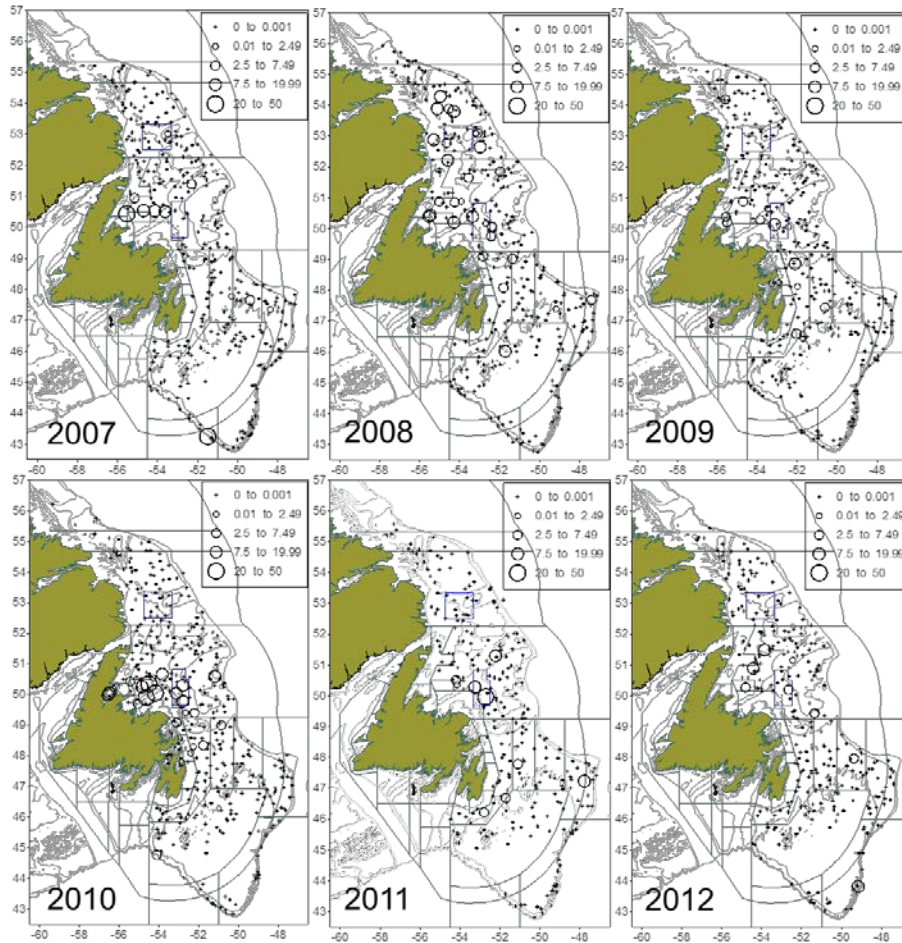


Figure 18: Percentage of fall trawl survey catches of male crabs with BCD from 2007-2012.

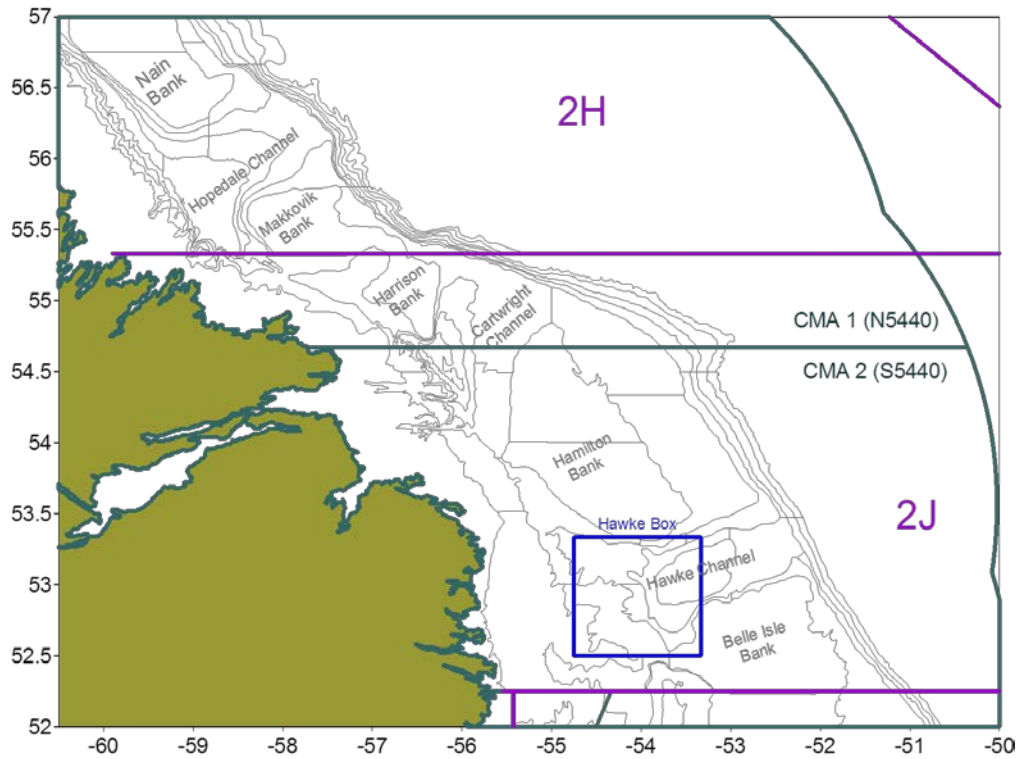


Figure 19: Map of Division 2HJ showing important bathymetric features and the Hawke Channel closed area.

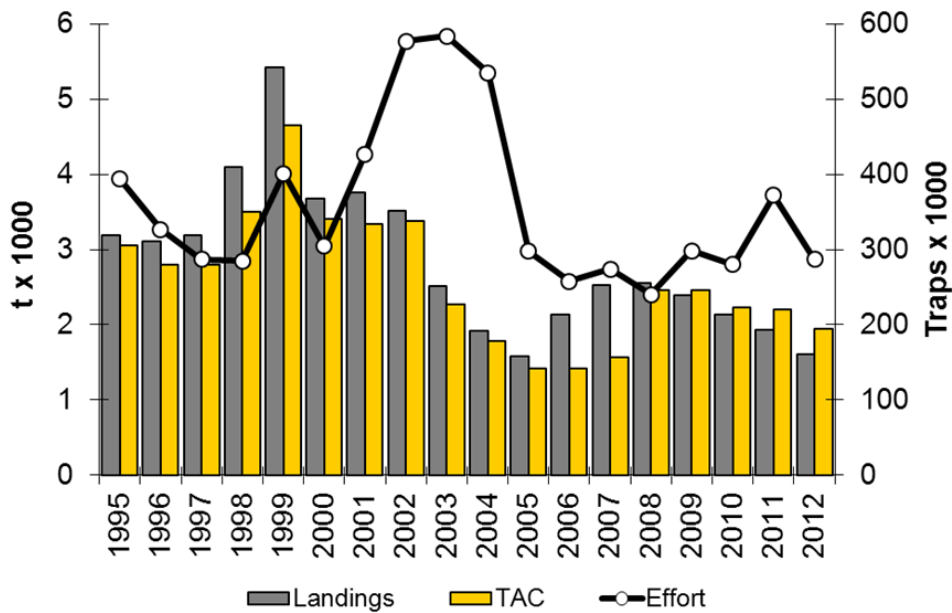


Figure 20: Trends in Div. 2HJ landings, TAC, and fishing effort.

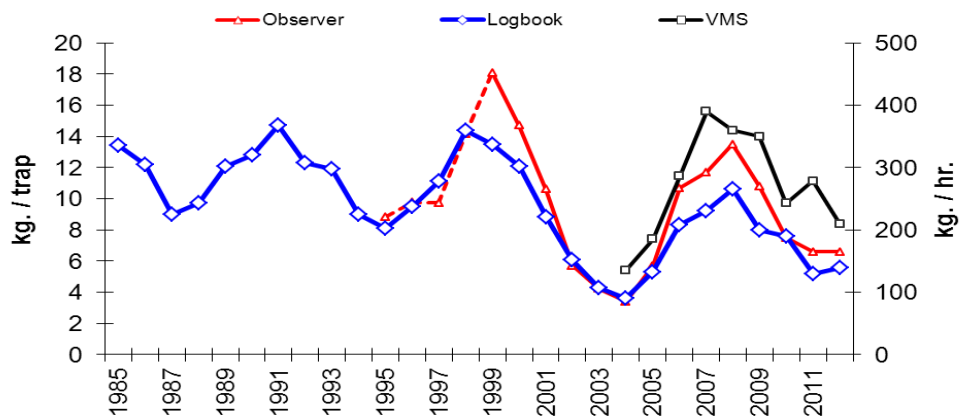


Figure 21: Trends in commercial logbook-based, observer-based, and VMS-based CPUE in the Div. 2HJ fishery.

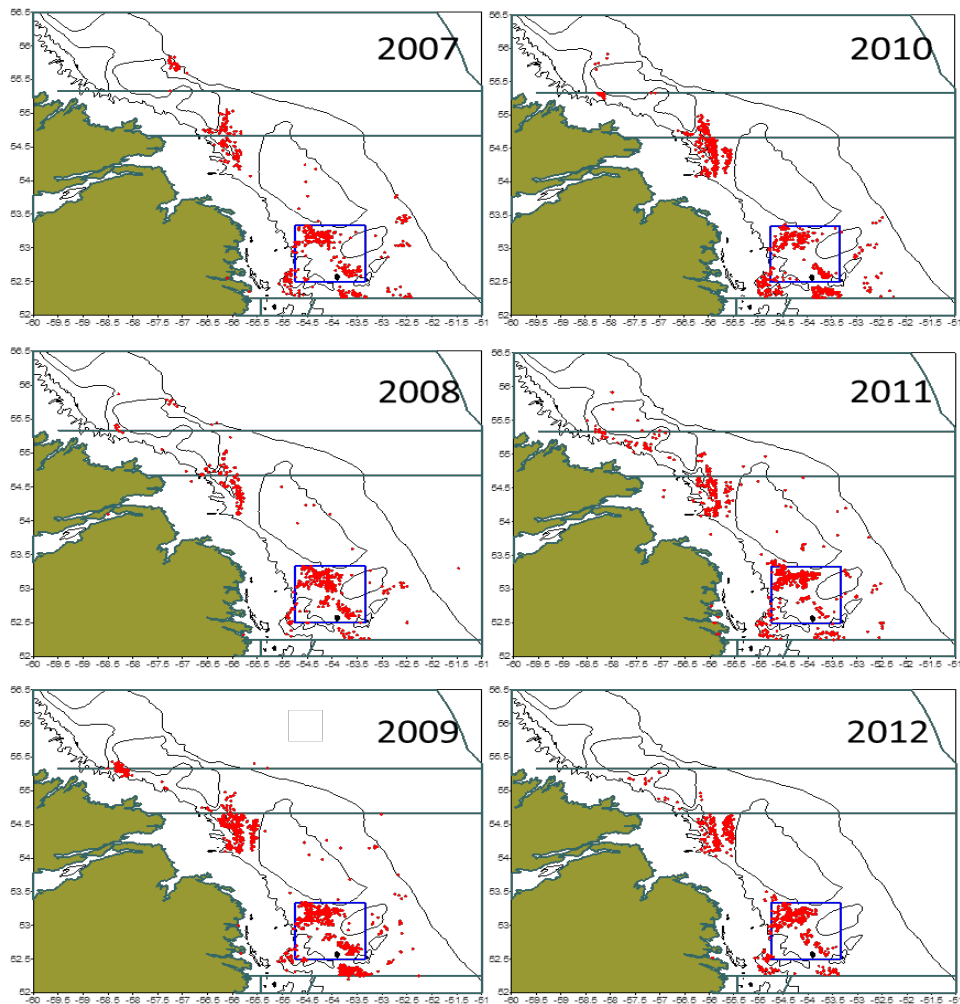


Figure 22: Spatial distribution of Div. 2HJ fishing effort by year.

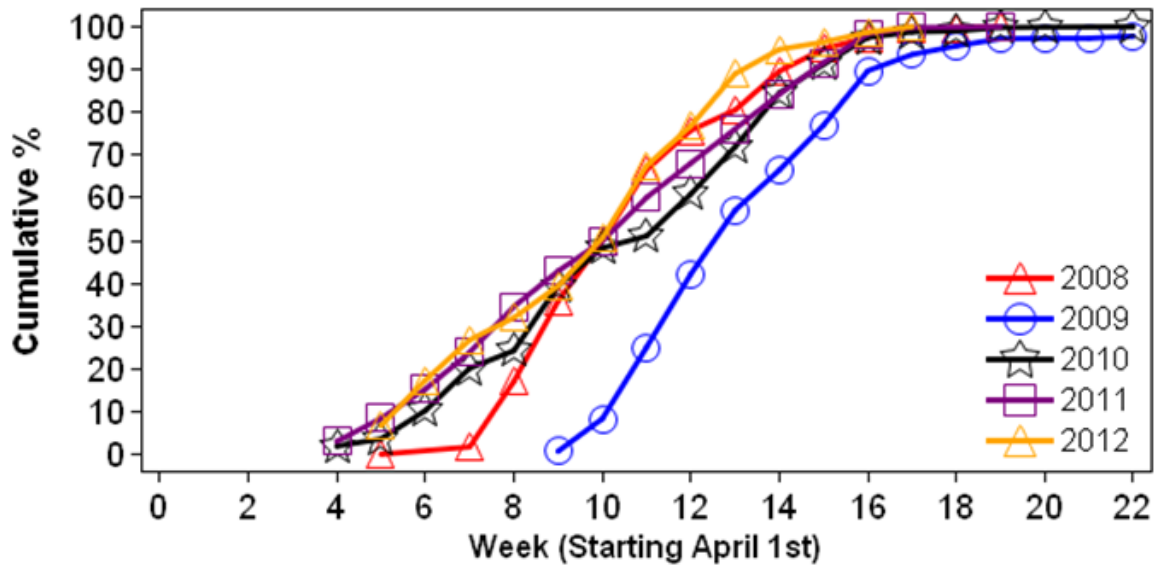


Figure 23: Seasonal trends in weekly fishing effort for Div. 2HJ

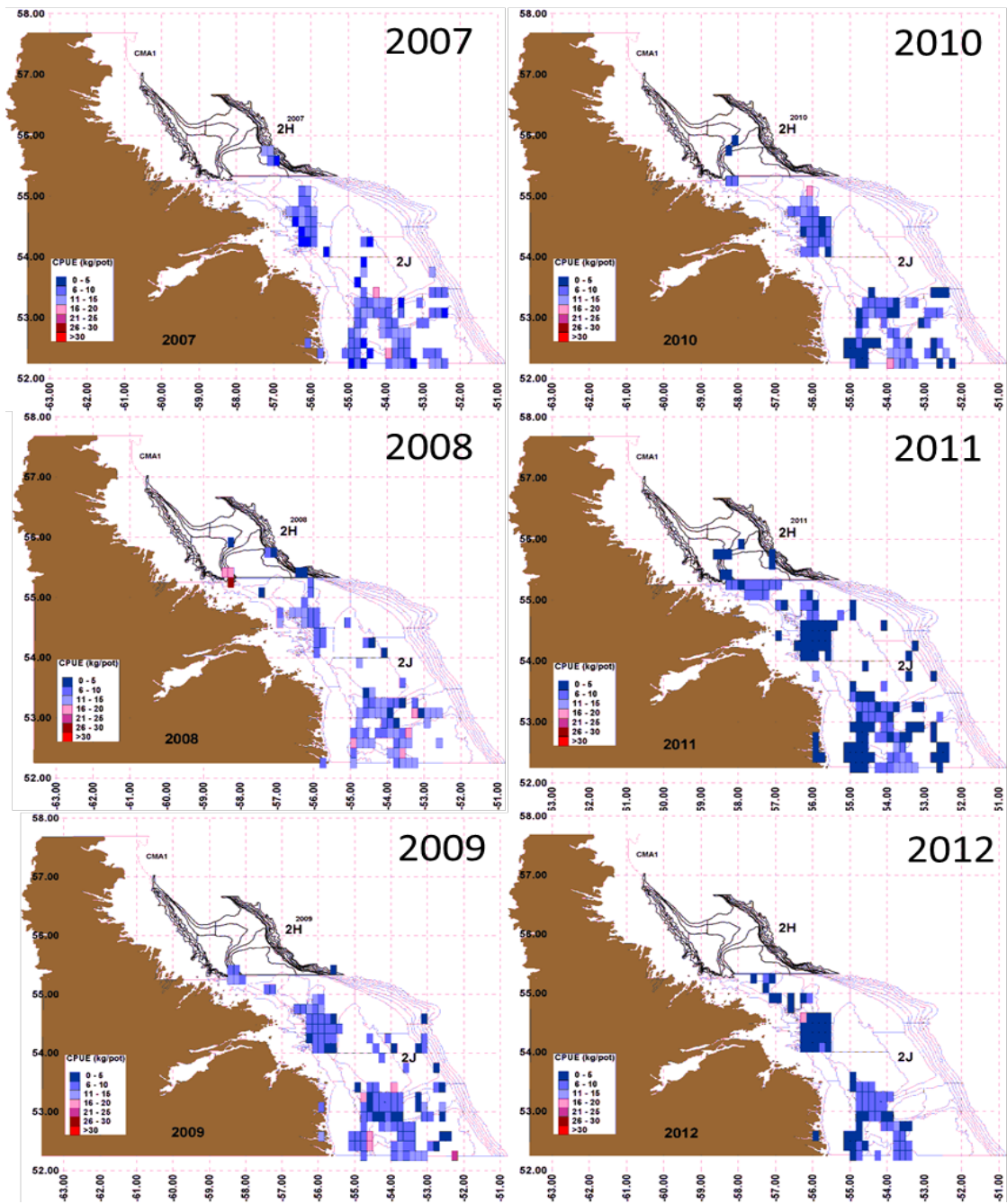


Figure 24: Spatial distribution of Div. 2HJ logbook CPUE by year.

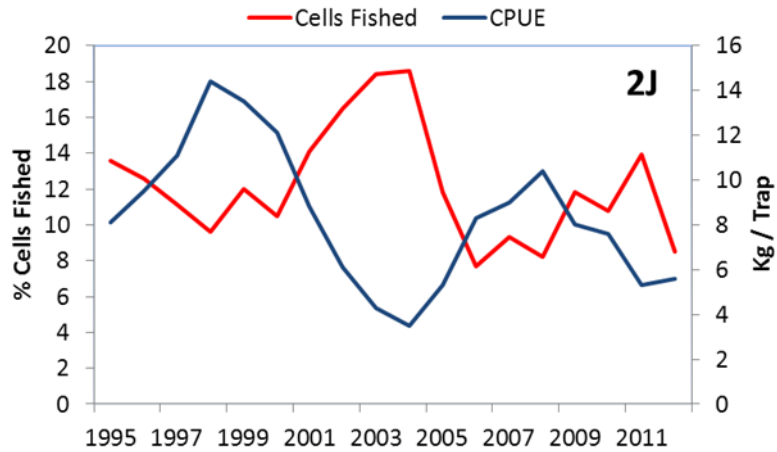


Figure 25: Trends in Div. 2J commercial CPUE vs. the percentage of 5' x 5' cells fished.

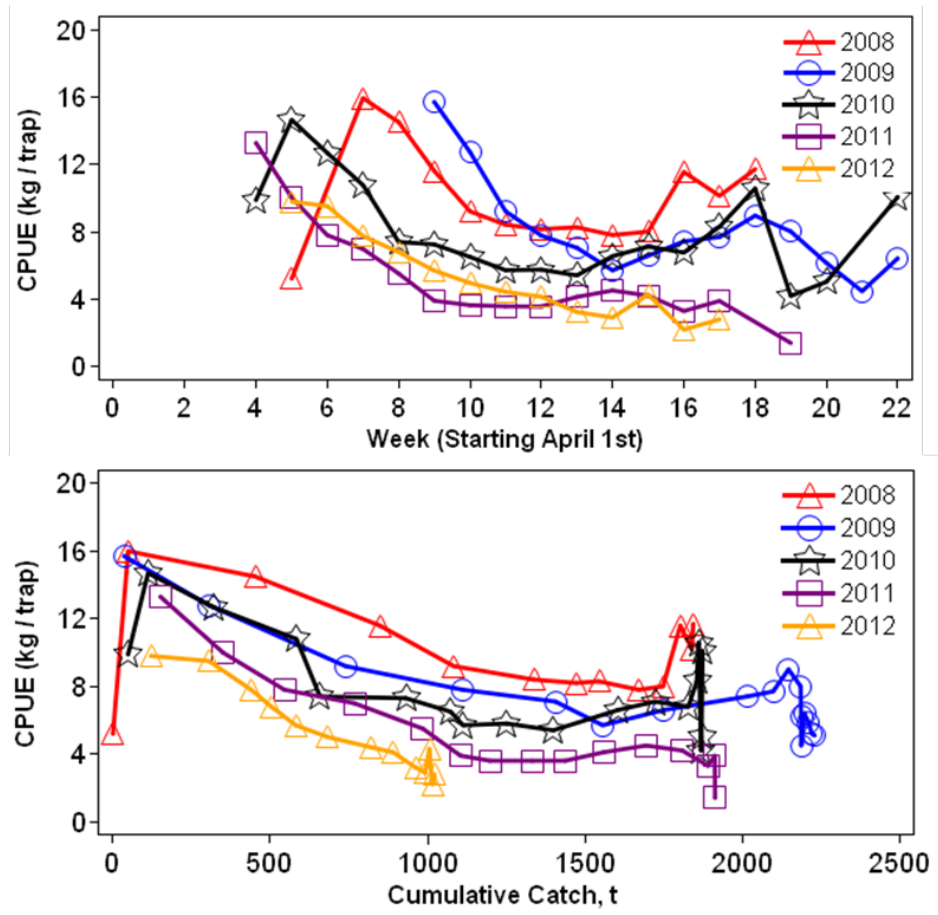


Figure 26: Seasonal trends in logbook CPUE for Div. 2HJ; by week (above), and in relation to cumulative catch (below).

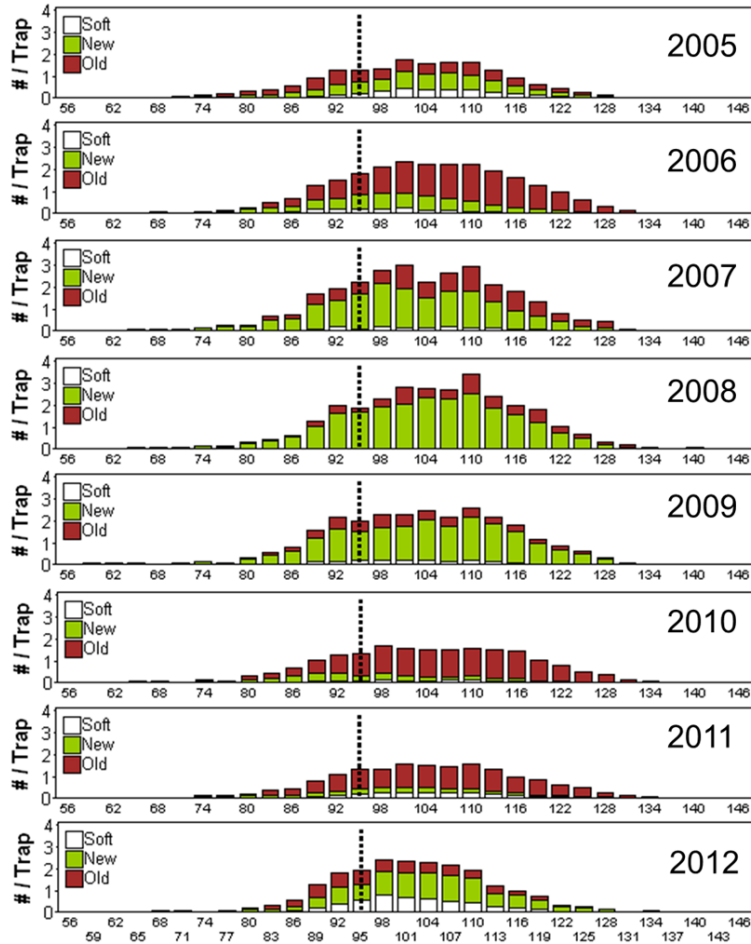


Figure 27: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Div. 2HJ. The vertical dashed line indicates the minimum legal size.

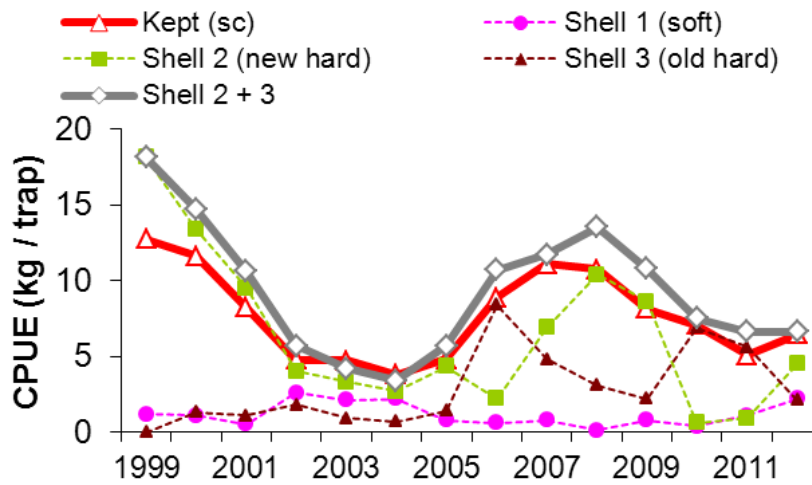


Figure 28: Trends in Division 2HJ observer catch rates of legal-sized crabs by shell condition from at-sea sampling and of all crabs kept based on set and catch records (sc).

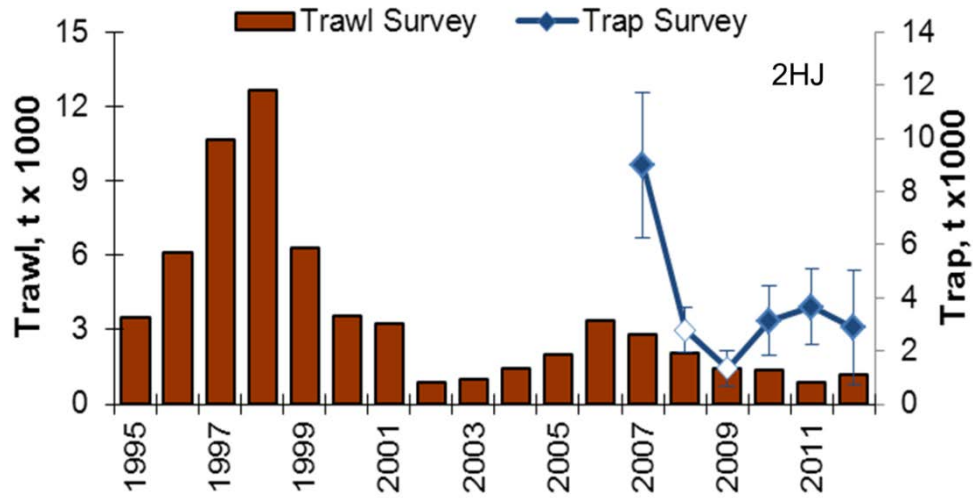


Figure 29: Trends in the Div. 2HJ fall trawl survey exploitable biomass index and the CPS trap survey exploitable biomass index. Only the Hawke Channel was surveyed in the 2008 and 2009 trap surveys.

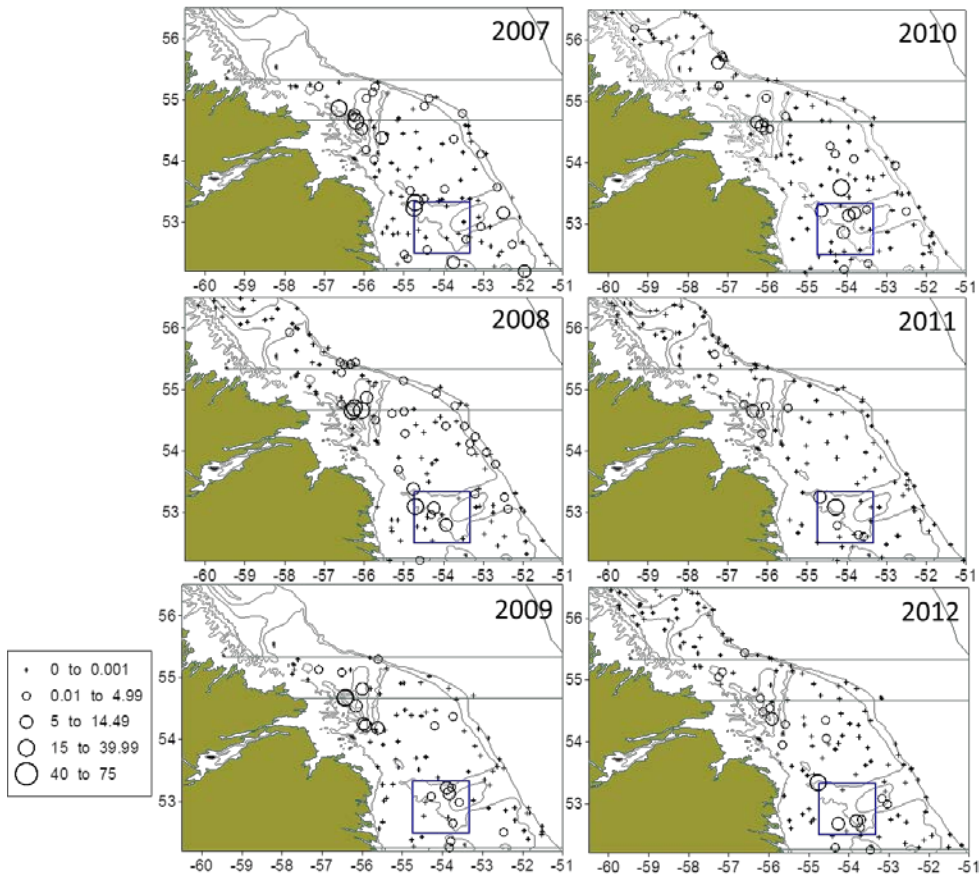


Figure 30: Spatial distribution of catches (number / set) of exploitable males in the Div. 2HJ fall trawl survey.

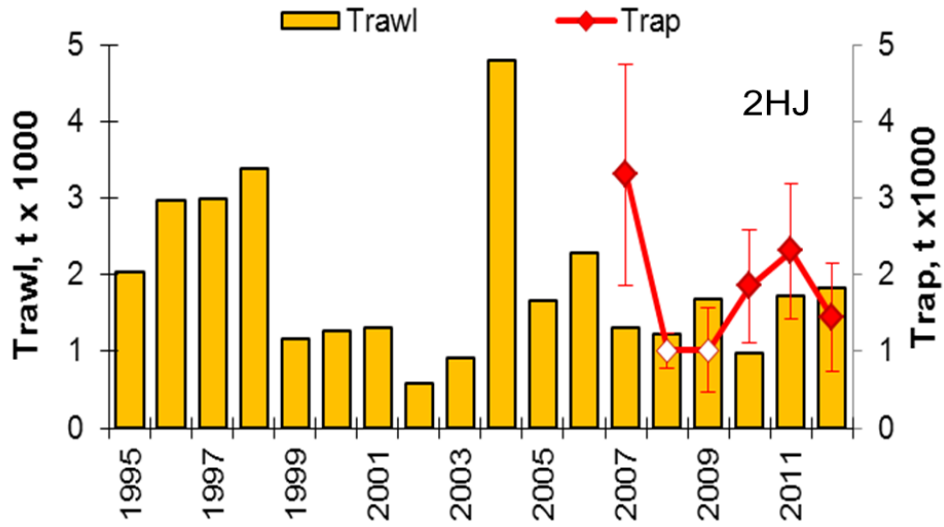


Figure 31: Trends in the Div. 2HJ fall trawl survey pre-recruit biomass index and the CPS trap survey pre-recruit biomass index. Only the Hawke Channel was surveyed in the 2008 and 2009 trap surveys.

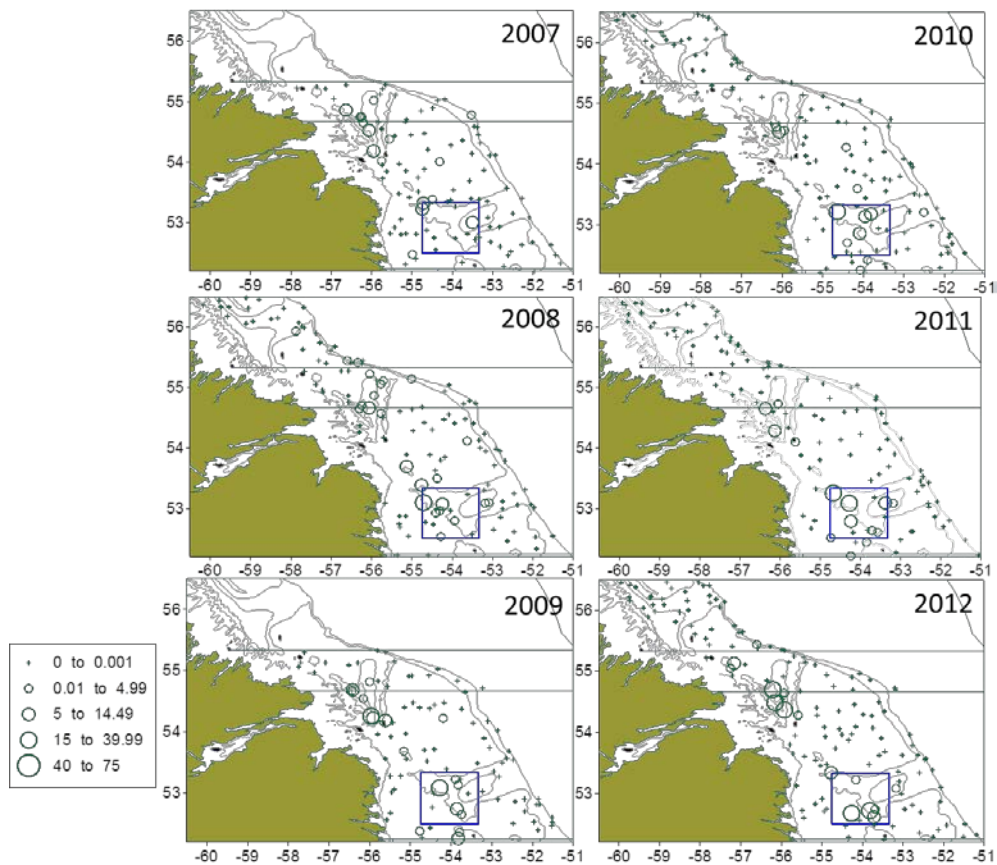


Figure 32: Spatial distribution of catches (number / set) of pre-recruit males in the Div. 2HJ fall trawl survey.

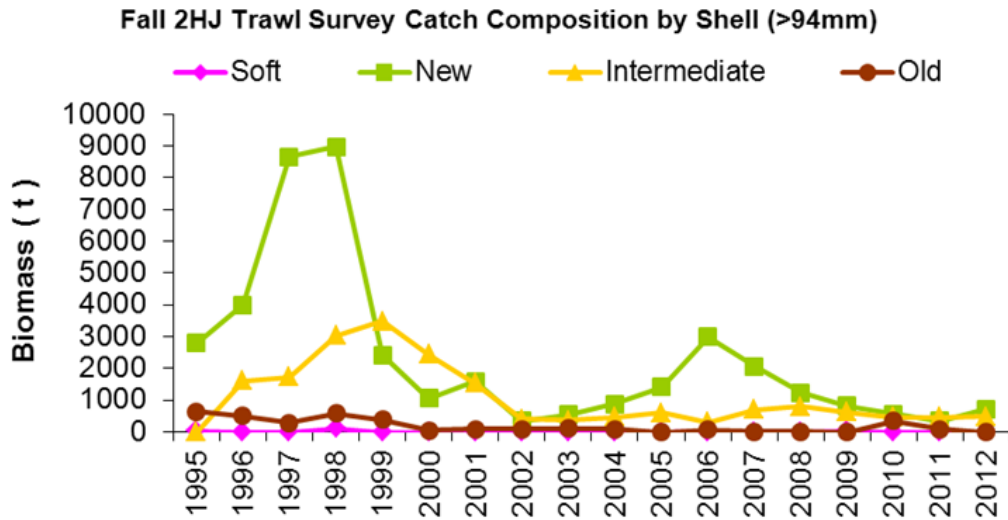


Figure 33: Trends, by shell condition, in biomass of legal-sized males for Div. 2HJ from fall trawl surveys.

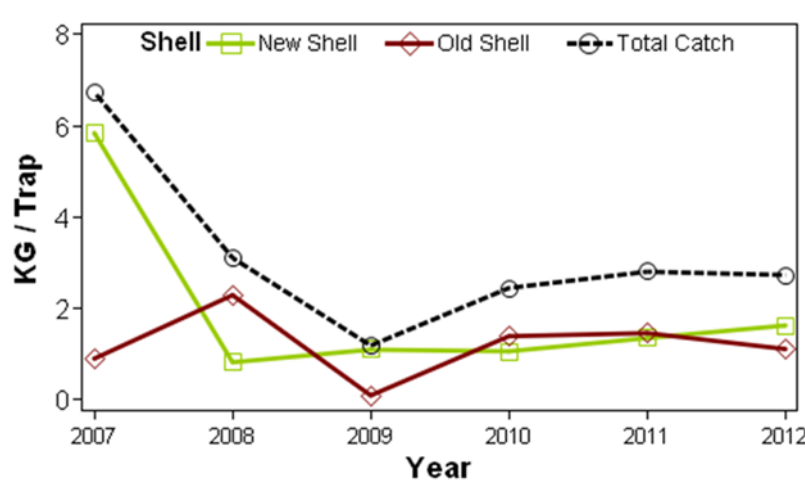


Figure 34: Trends in CPUE by shell condition for legal-sized crabs from core stations in the Div. 2J CPS trap survey.

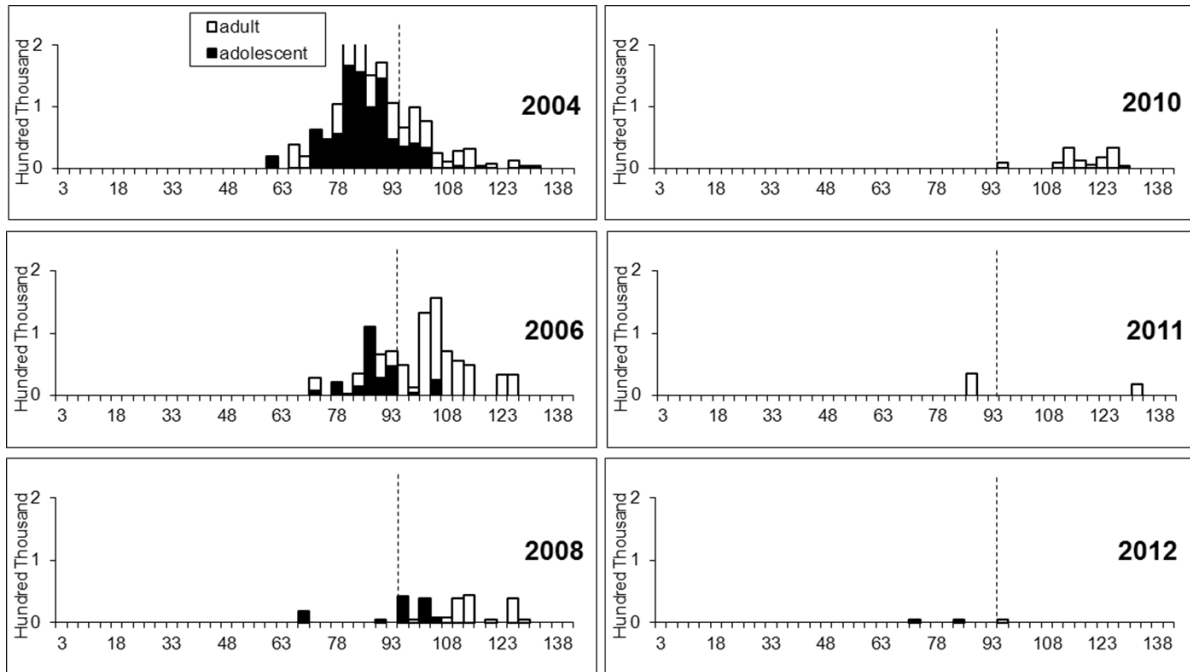


Figure 35: Abundance indices by carapace width for Div. 2H juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys.

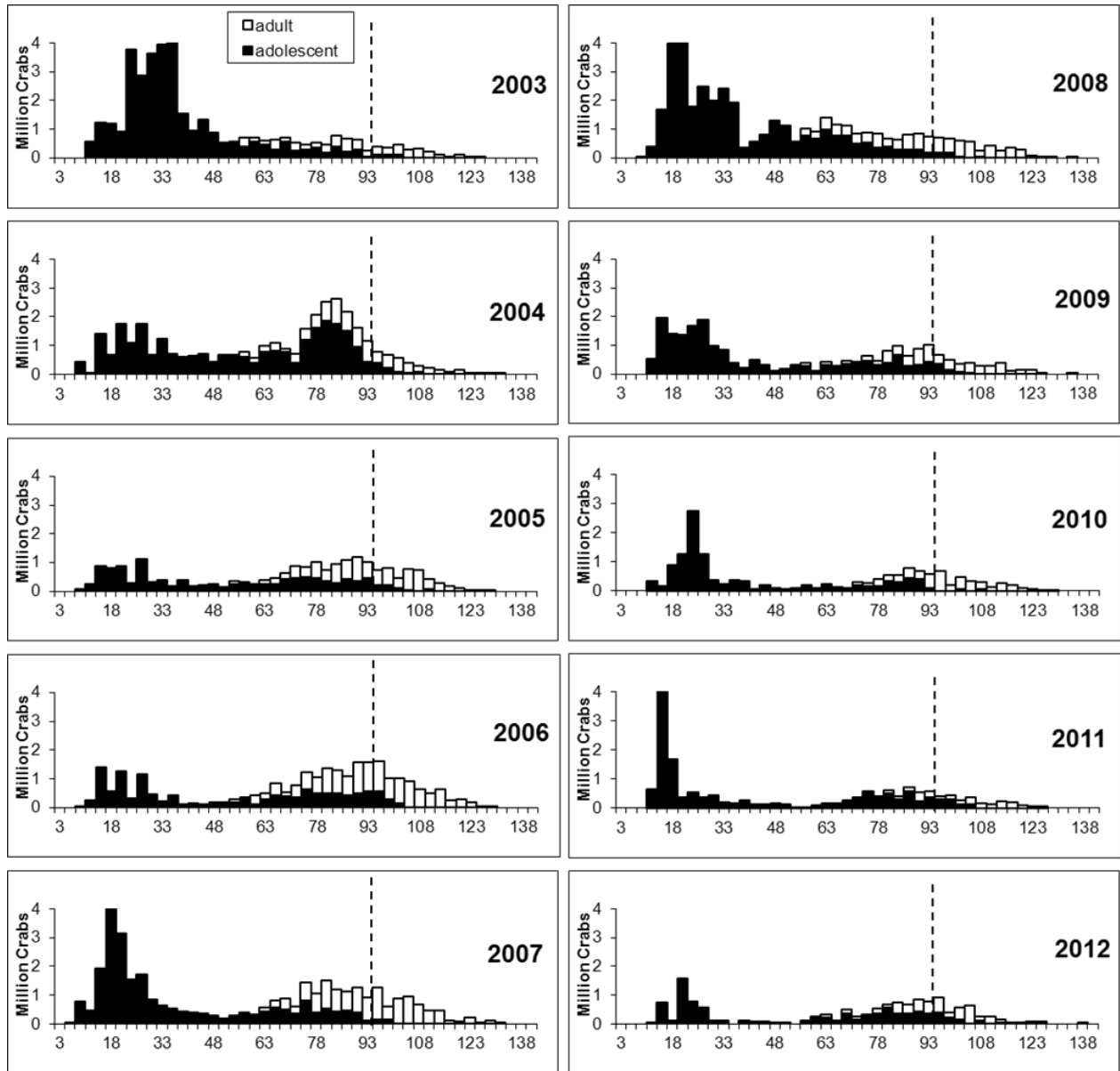


Figure 36. Abundance indices by carapace width for Div. 2J juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys.

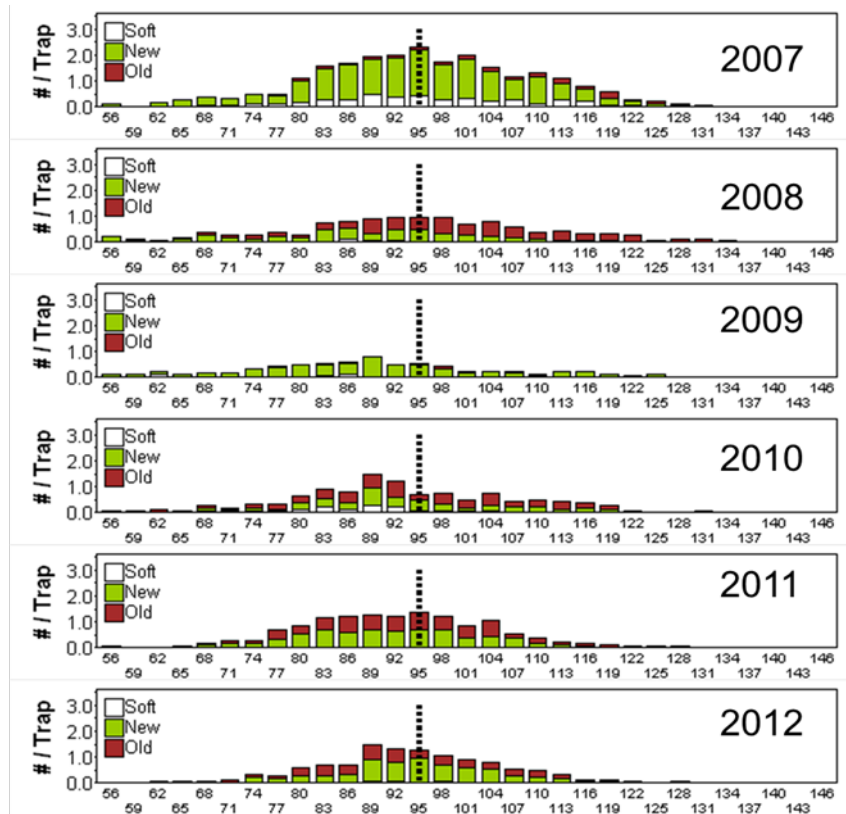


Figure 37: Trends in male carapace width distributions from core stations in the Div. 2J CPS trap survey. The vertical dashed line indicates the minimum legal size.

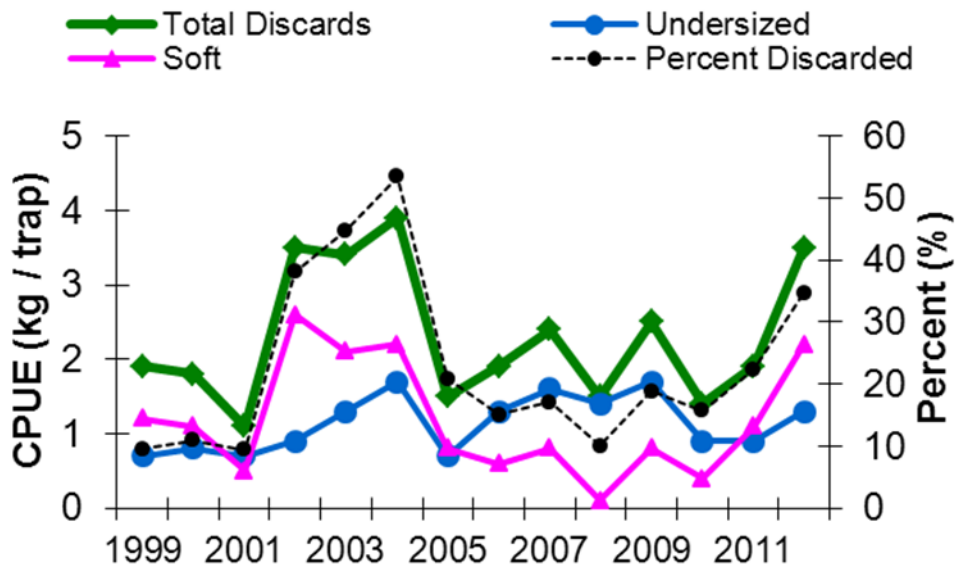


Figure 38: Trends in Division 2J observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

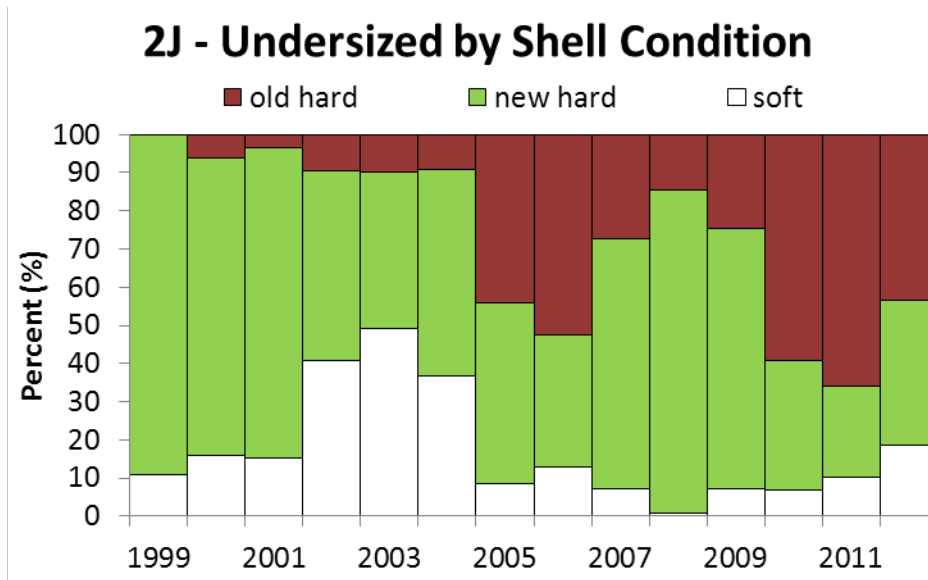


Figure 39: Trends in shell condition of 76-94mm CW crabs from Division 2J observer at-sea sampling.

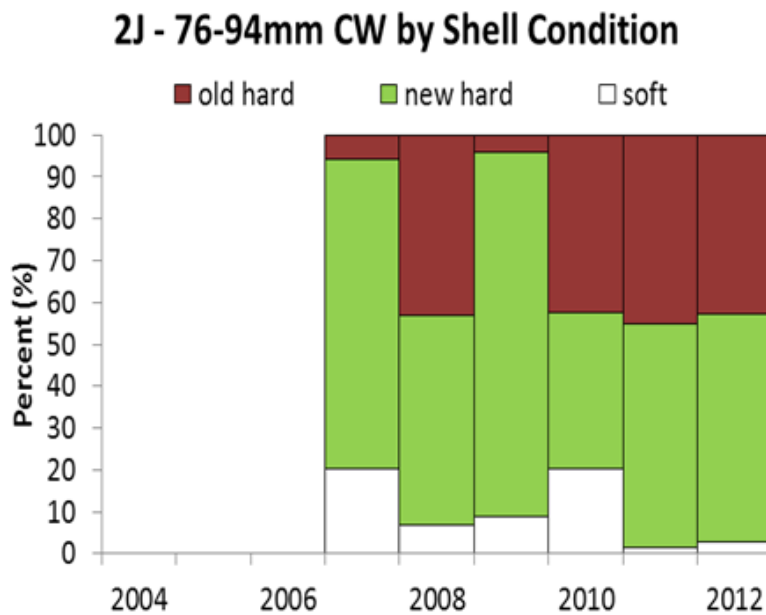


Figure 40: Trends in shell condition of 76-94mm CW crabs from Division 2J CPS trap survey.

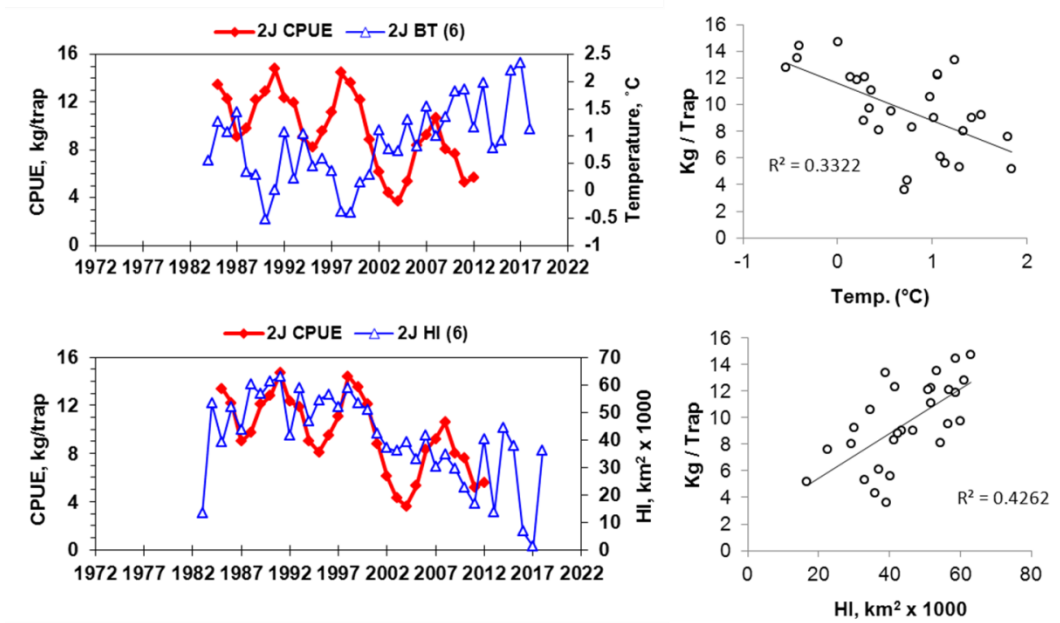


Figure 41: Trends in the Div. 2HJ CPUE vs. bottom temperature (above) and spatial extent of <2 degree water (below) at a six year lag (left), with corresponding scatter plots (right).

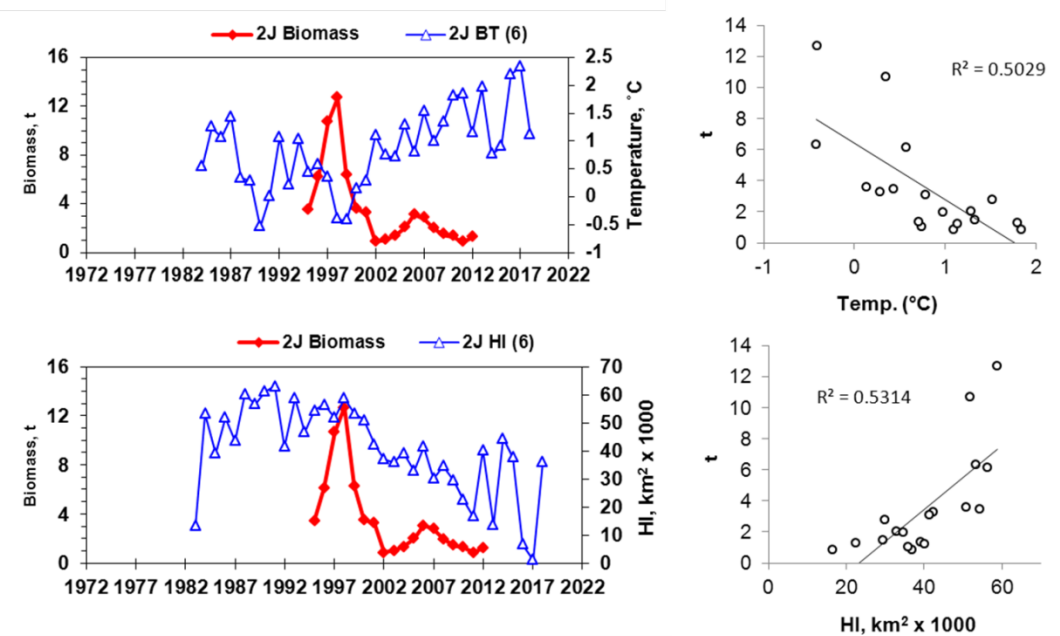


Figure 42: Trends in the Div. 2HJ exploitable biomass index vs. bottom temperature (above) and spatial extent of <2 degree water (below) at a six year lag (left), with corresponding scatter plots (right).

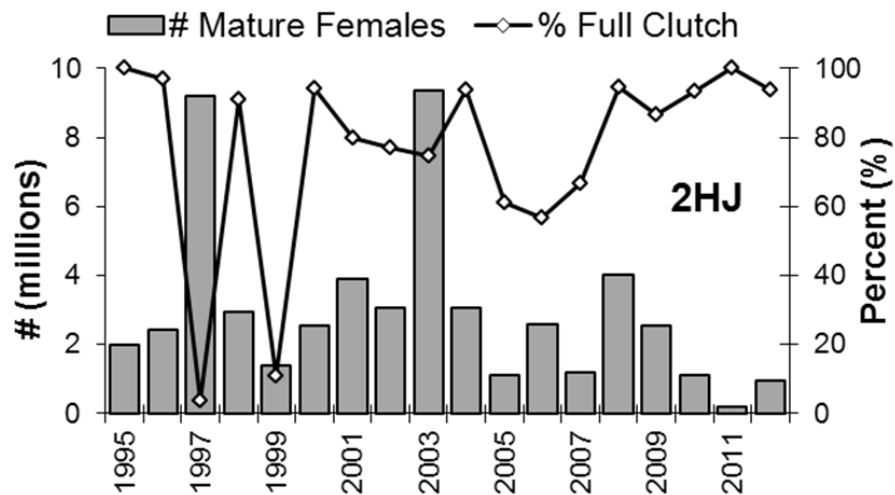


Figure 43: Trends in abundance of mature females as well as the percentage of mature females bearing full clutches of viable eggs in Div. 2HJ from fall multi-species surveys.

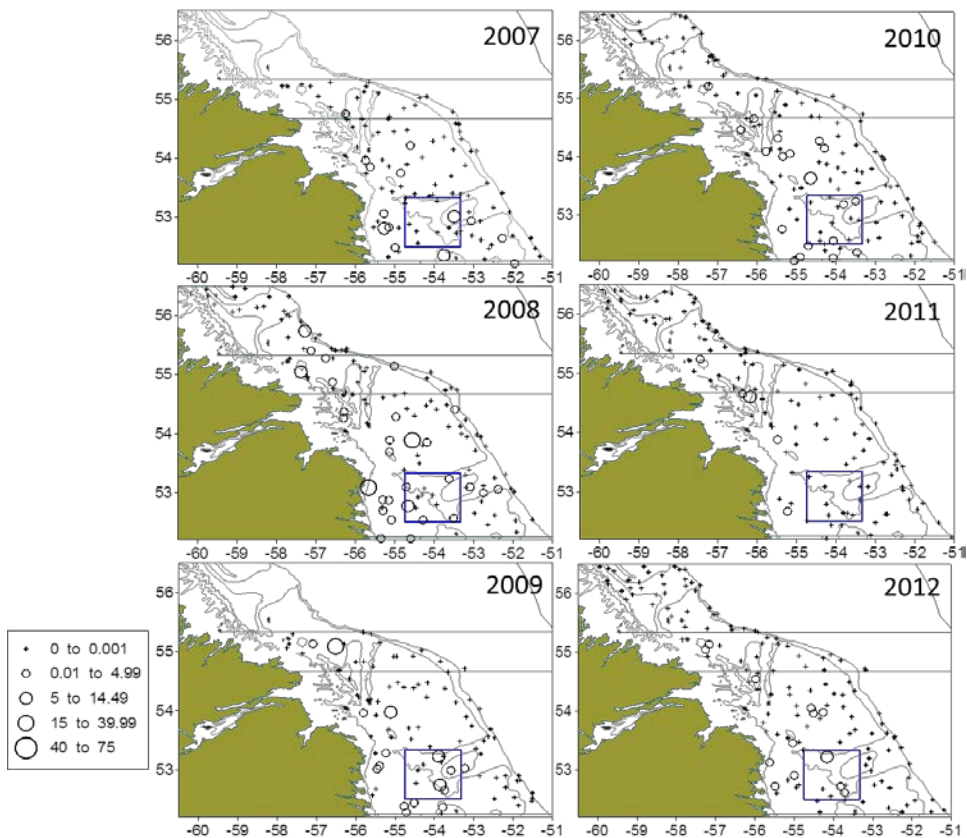


Figure 44: Spatial distribution of catch rates (number / set) of mature females in the Div. 2HJ fall trawl survey.

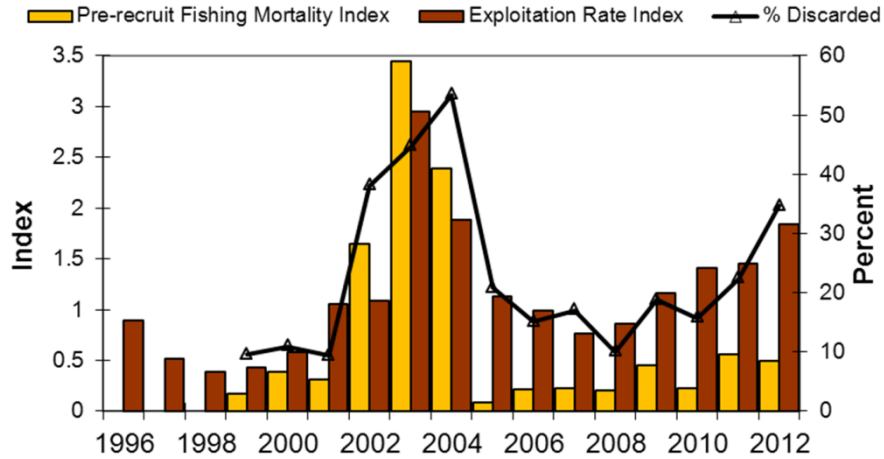


Figure 45: Trends in Div. 2HJ mortality indices (the exploitation rate index and the pre-recruit fishing mortality rate index) and in the percentage of the catch discarded in the fishery.

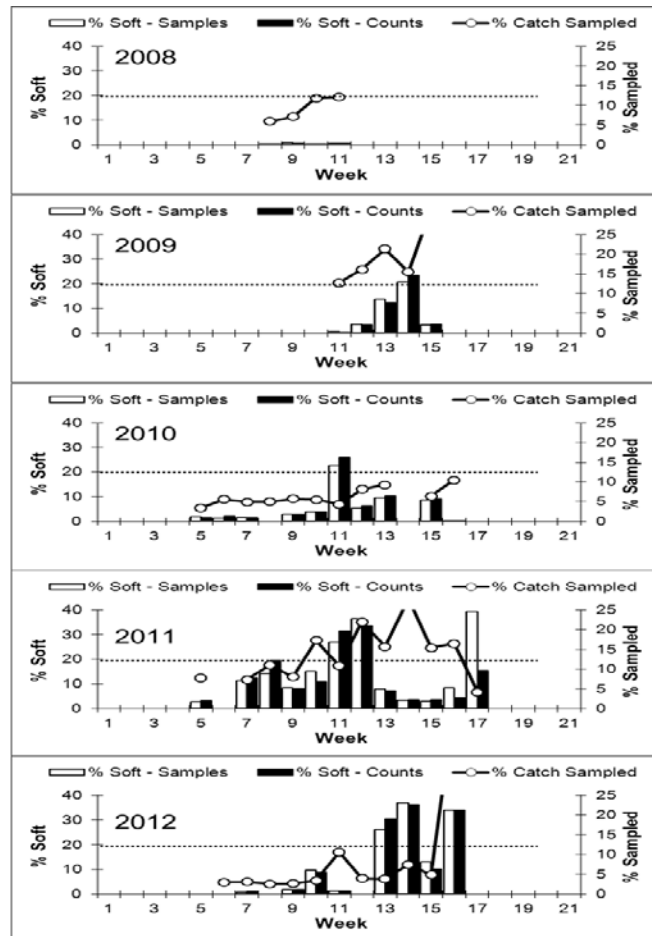


Figure 46: Trends in weekly percentages of soft-shell crab in the Div. 2J fishery from at-sea sampling by observers.

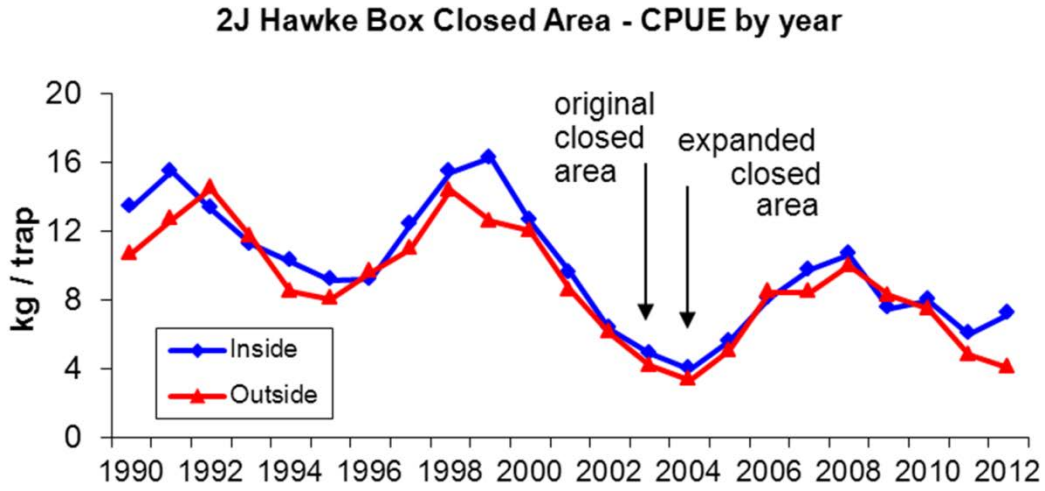


Figure 47: Trends in Div. 2J commercial logbook CPUE inside vs. outside the Hawke Channel closed area.

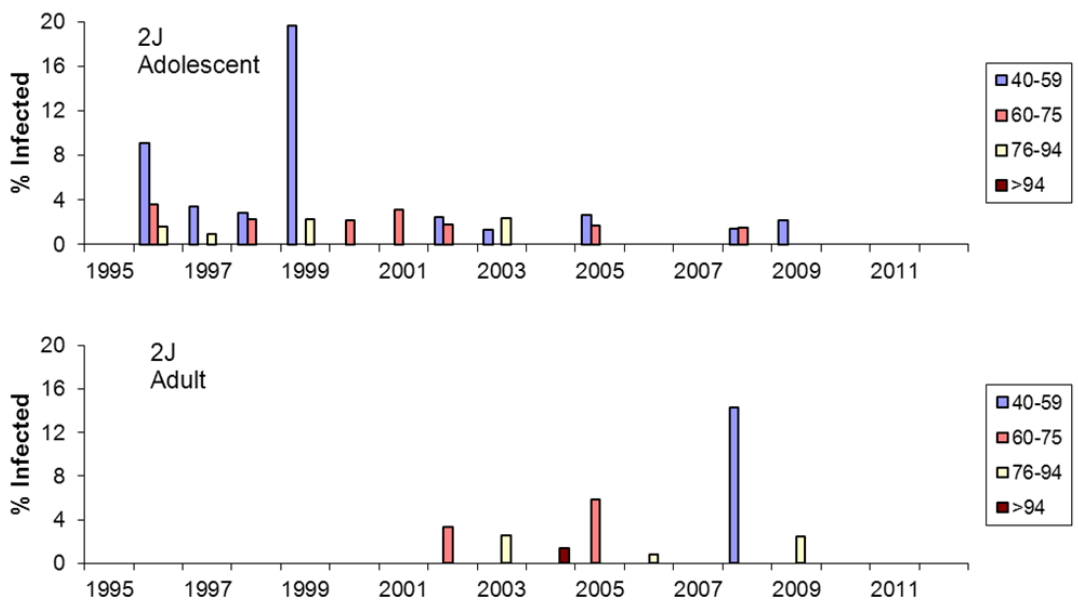


Figure 48: Annual trends in prevalence of BCD in new-shelled adolescent (above) and adult (below) males by size group from Div. 2J fall trawl surveys.

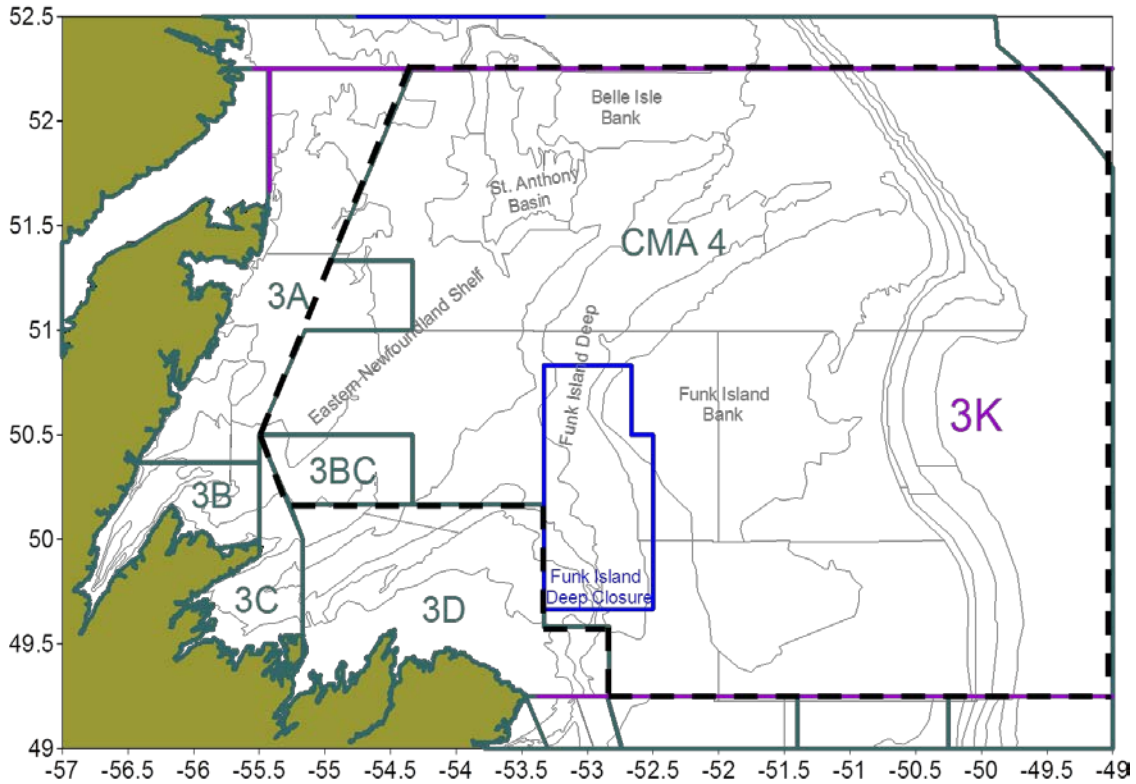


Figure 49: Map of Division 3K showing crab management areas and important bathymetric features as well as the Funk Island Deep closed area (blue box). Dashed perimeter indicates the offshore area.

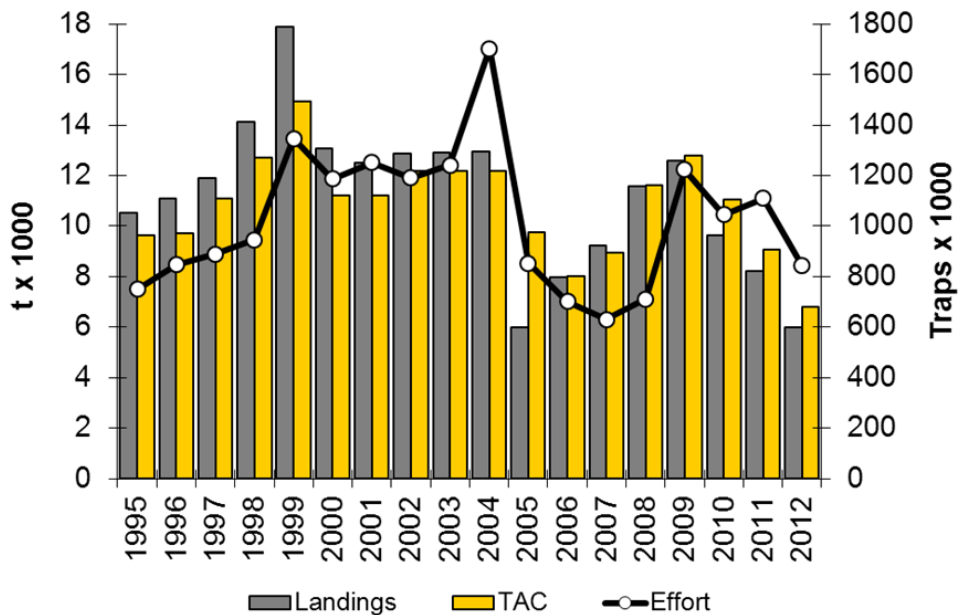


Figure 50: Trends in Div. 3K offshore landings, TAC, and fishing effort.

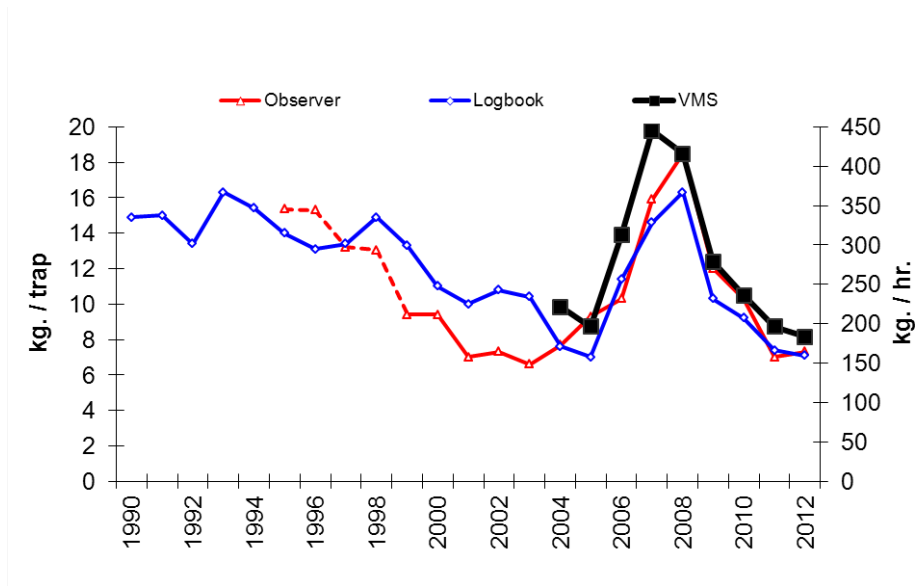


Figure 51: Trends in commercial logbook-based, observer-based, and VMS-based CPUE in the Div. 3K offshore fishery.

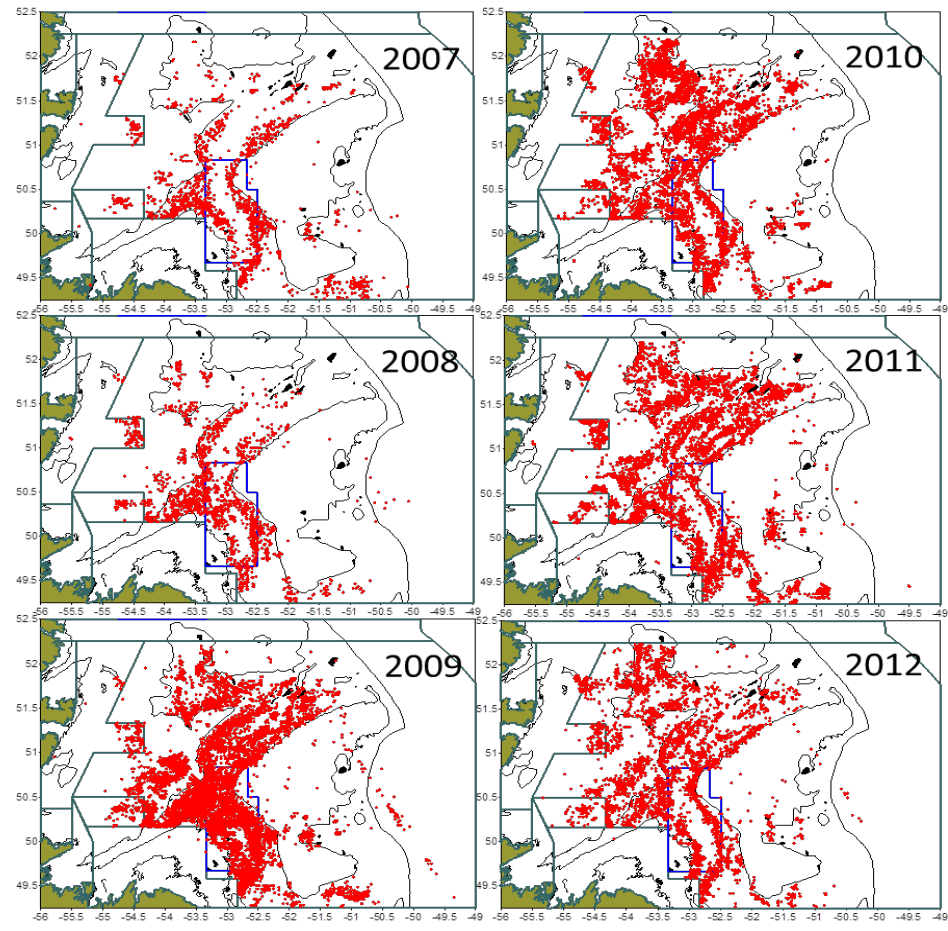


Figure 52: Spatial distribution of Div. 3K offshore fishing effort by year.

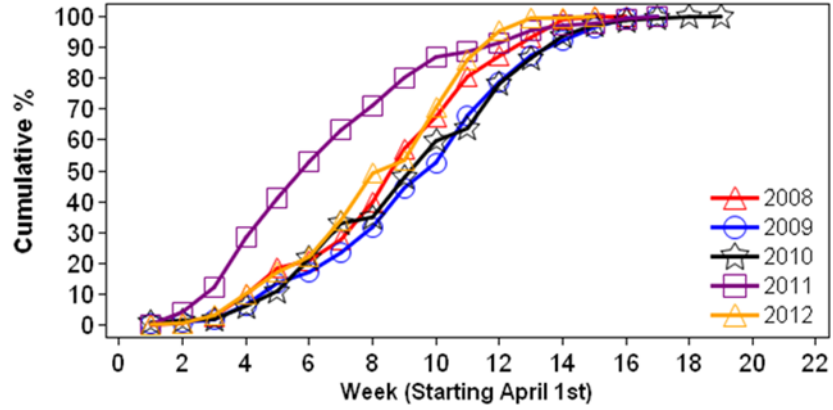


Figure 53: Seasonal trends in fishing effort for Div. 3K offshore.

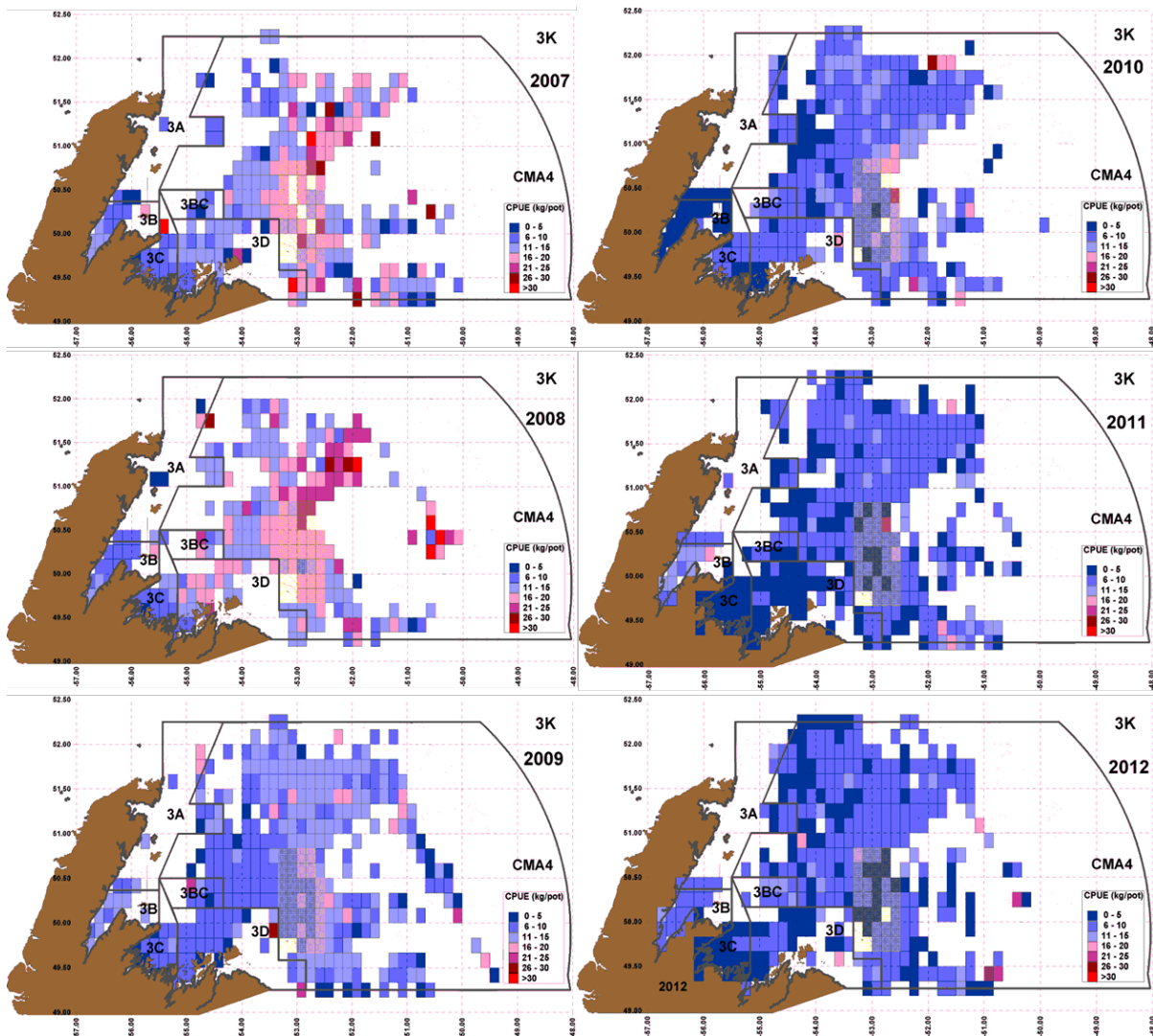


Figure 54: Spatial distribution of Div. 3K logbook CPUE by year.

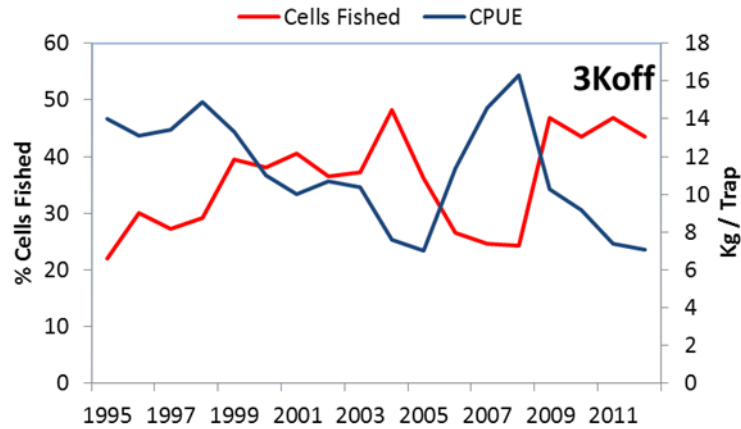


Figure 55: Trends in Div. 3K offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

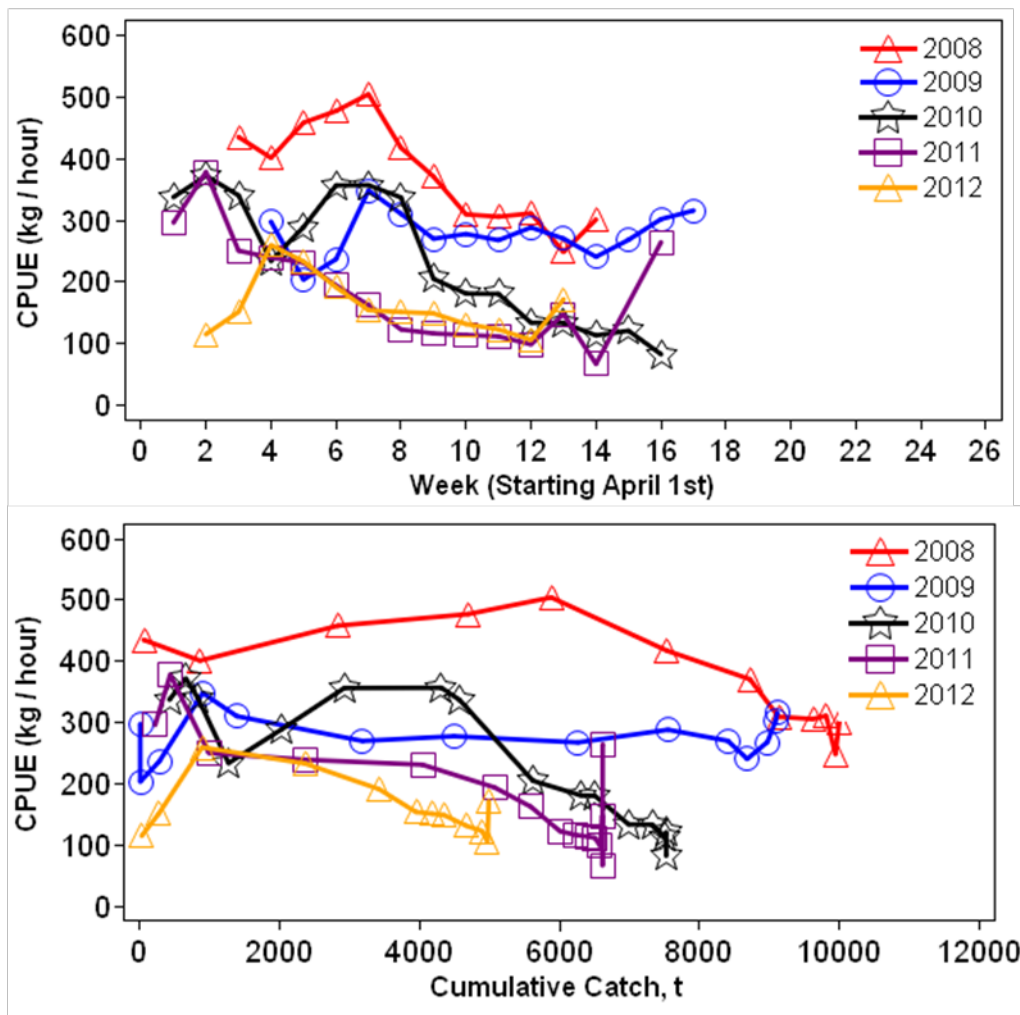


Figure 56: Seasonal trends in VMS-based CPUE for Div. 3K offshore; by week, (above) and in relation to cumulative catch (below).

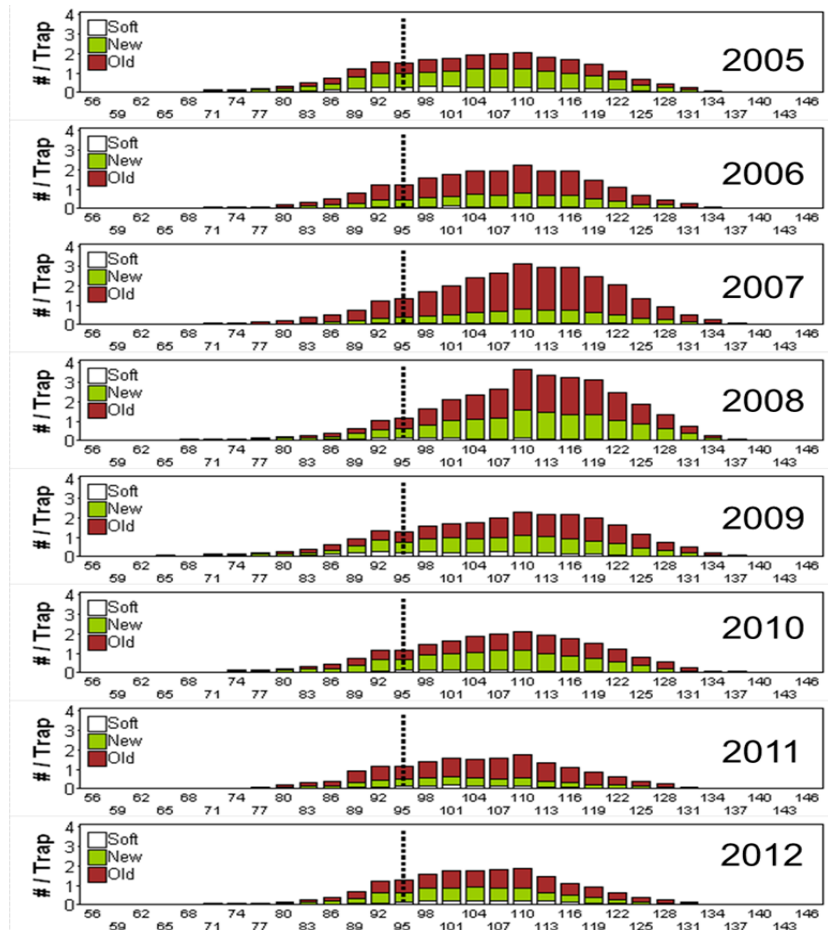


Figure 57: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Div. 3K offshore. The vertical dashed line indicates the minimum legal size.

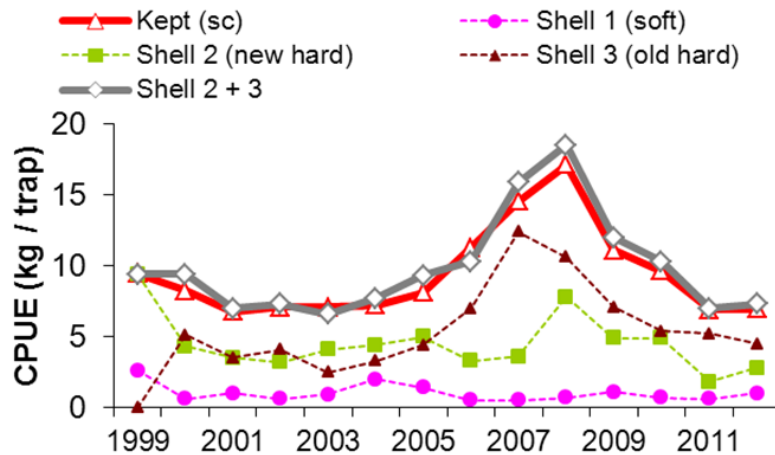


Figure 58: Trends in Division 3K offshore observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

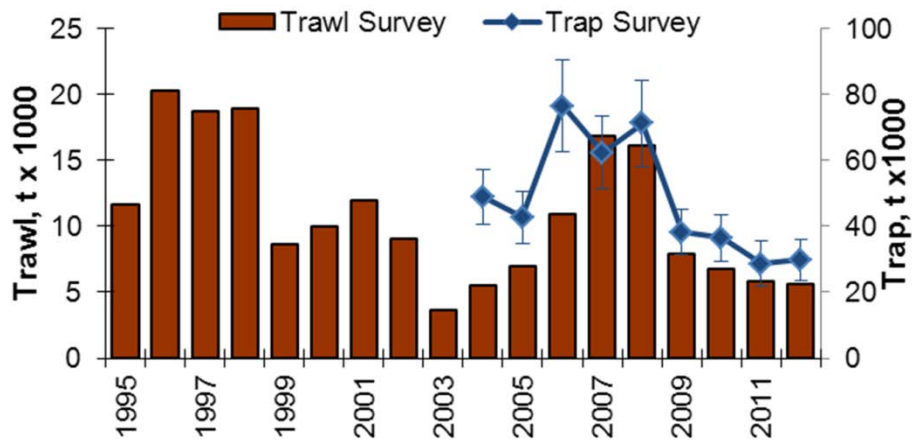


Figure 59: Trends in the Div. 3K offshore fall trawl survey exploitable biomass index and the CPS trap survey exploitable biomass index.

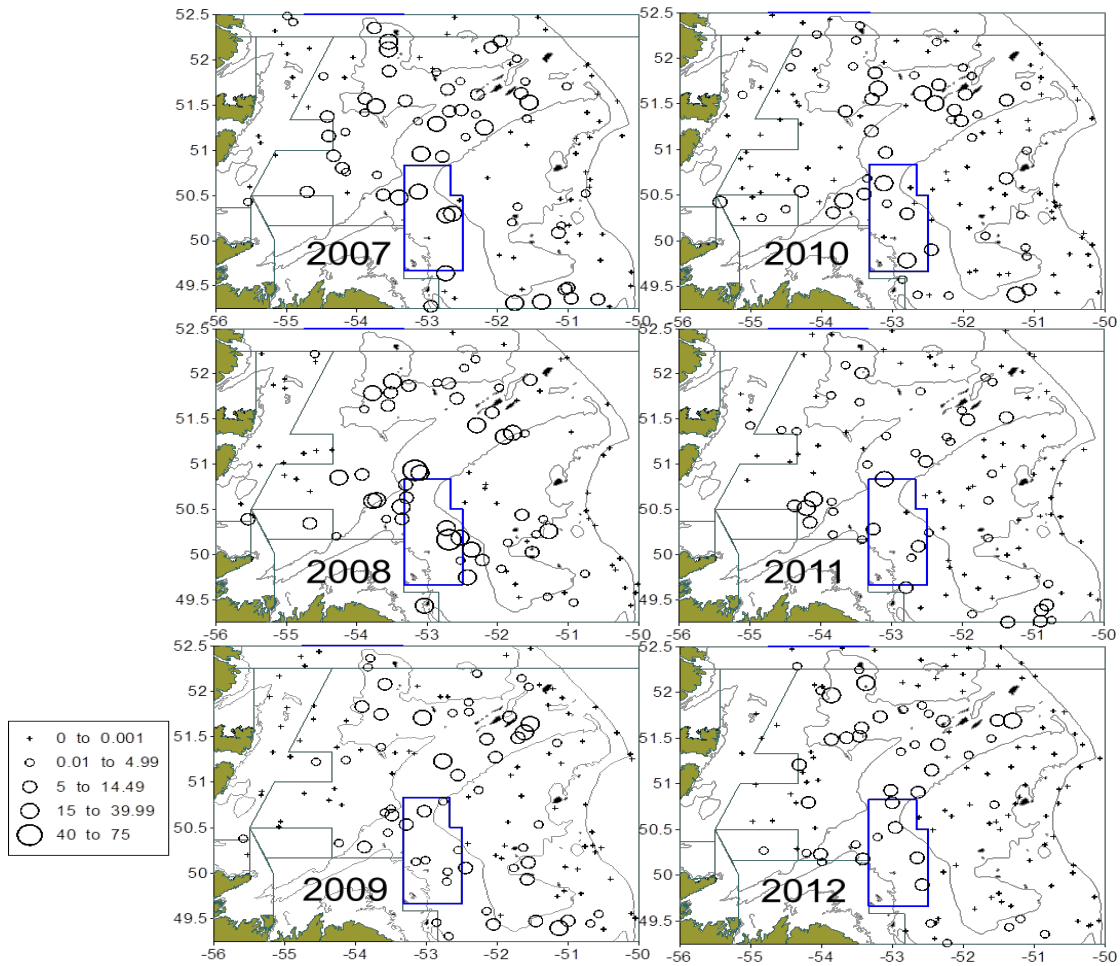


Figure 60. Spatial distribution of catches (number / set) of exploitable snow crab in Div. 3K offshore trawl survey.

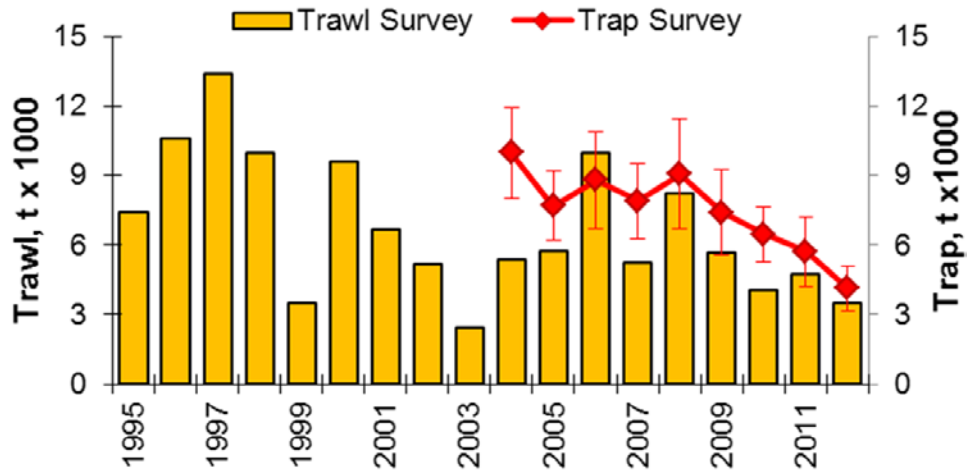


Figure 61: Trends in the Div. 3K fall trawl survey pre-recruit biomass index and the CPS trap survey pre-recruit biomass index.

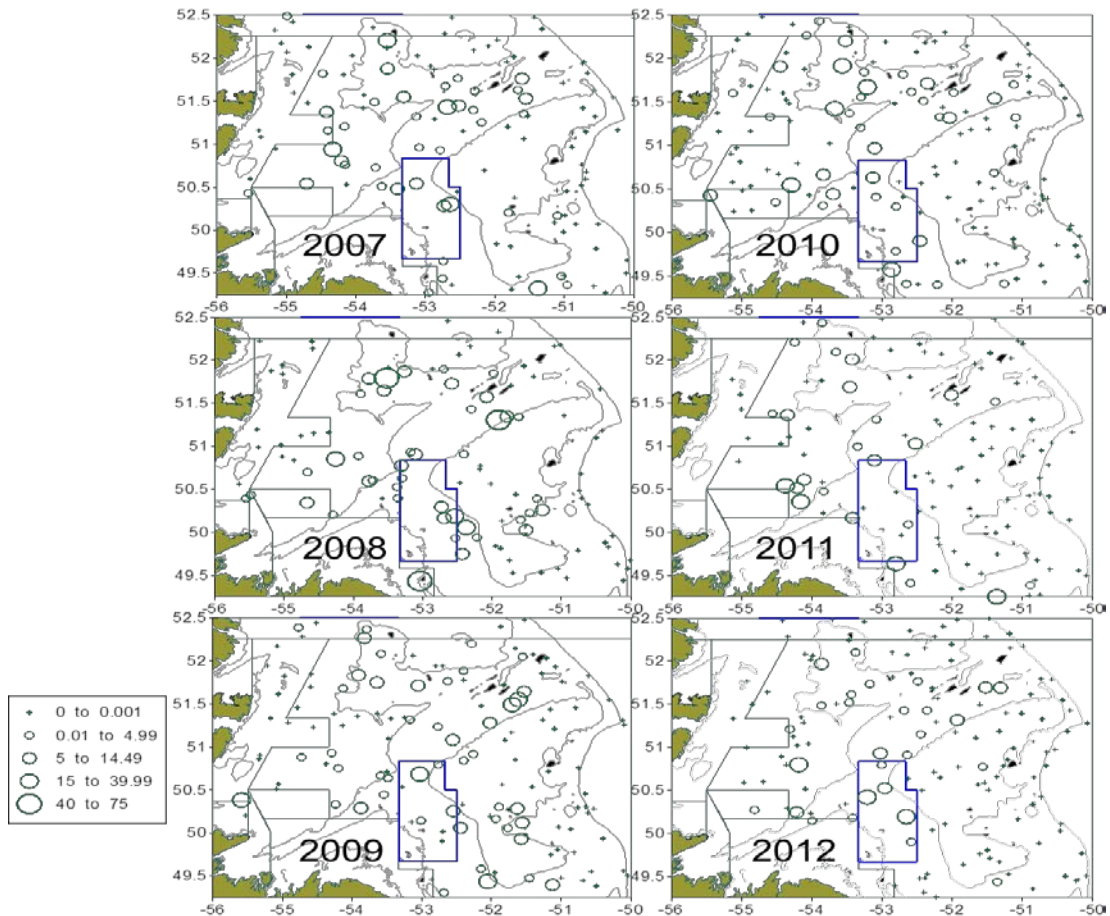


Figure 62. Spatial distribution of catches (number / set) of pre-recruit snow crab in the Div. 3K offshore trawl survey.

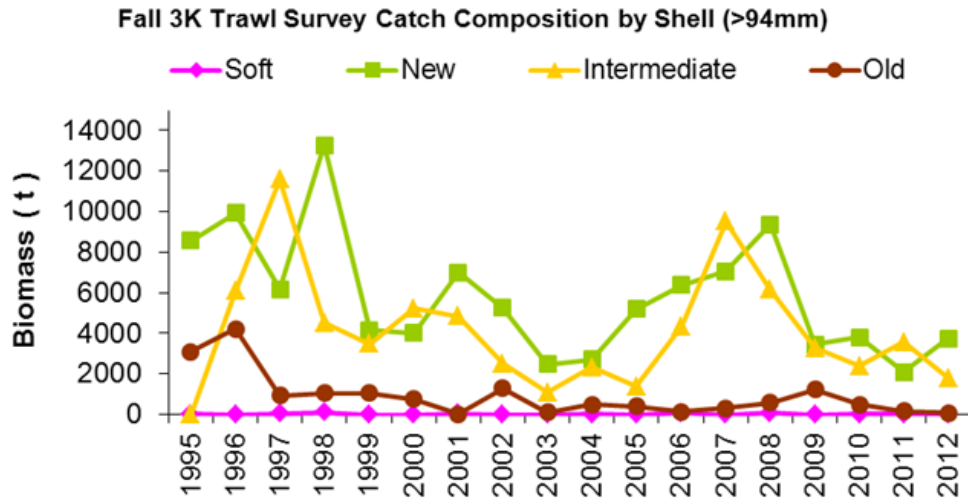


Figure 63: Trends, by shell condition, in biomass of legal-sized males for Div. 3K offshore from fall trawl surveys.

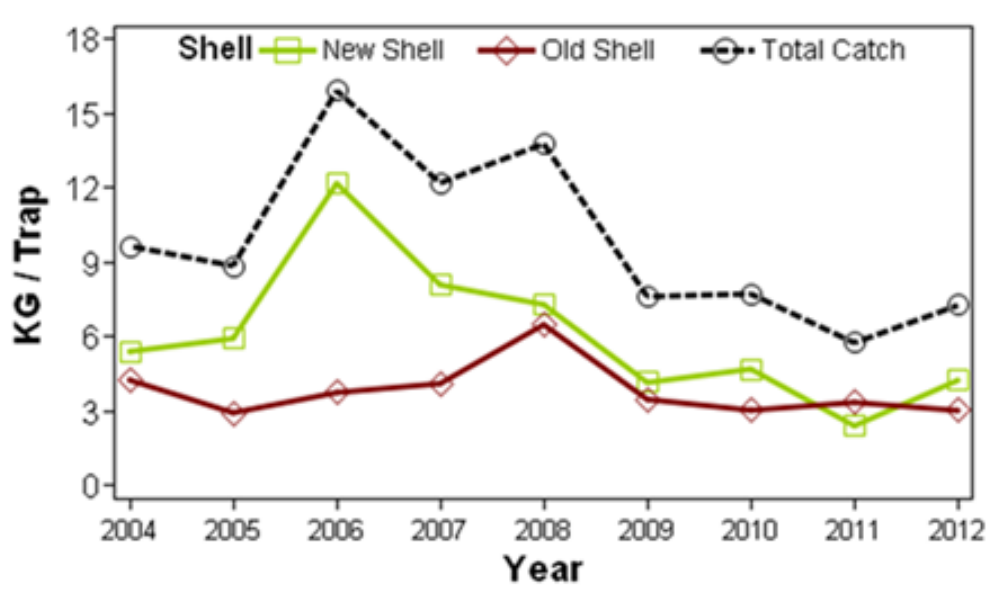


Figure 64: Trends in CPUE by shell condition for legal-sized crabs from core stations in the Div. 3K offshore CPS trap survey.

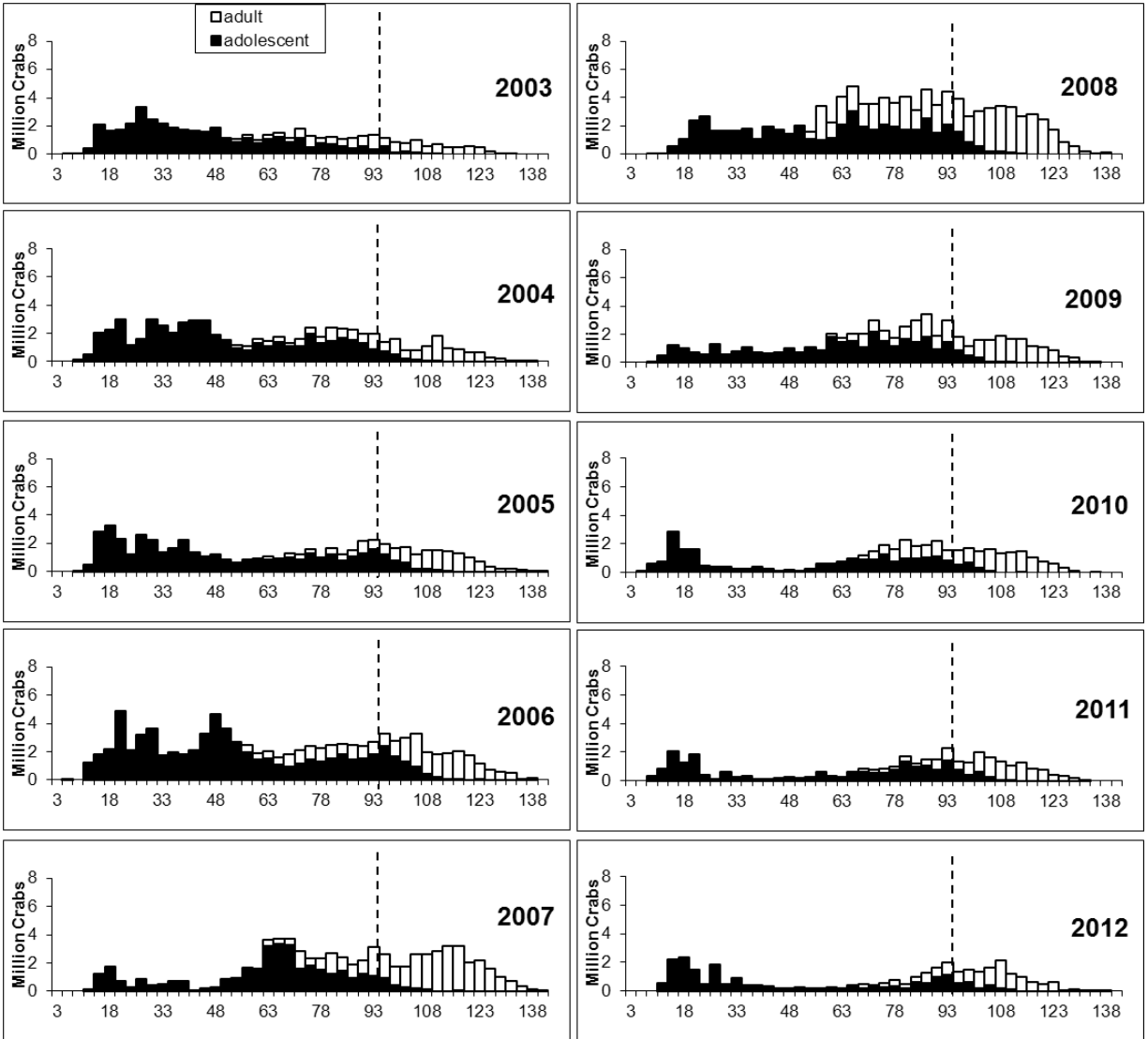


Figure 65: Abundance indices by carapace width for Div. 3K offshore juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys.

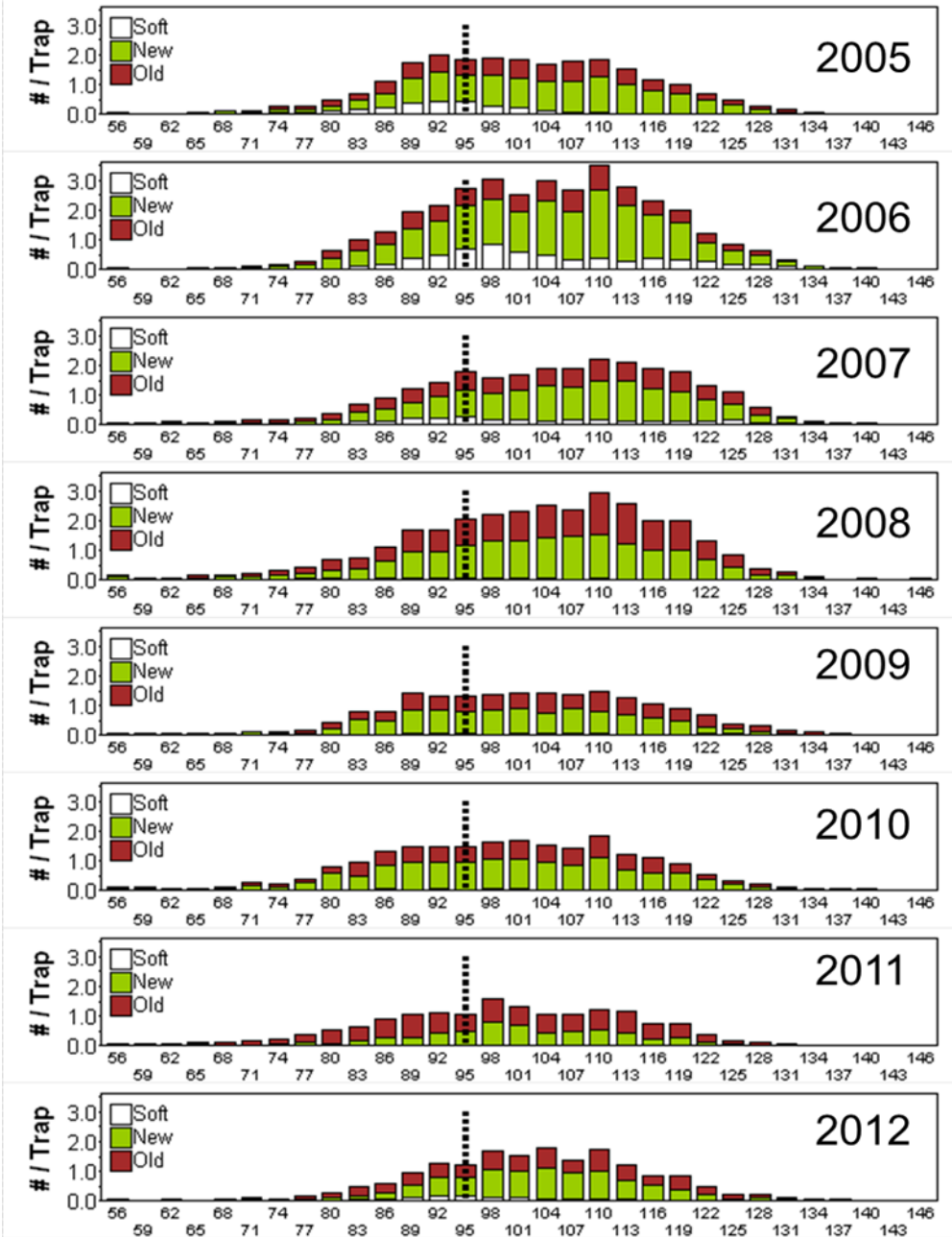


Figure 66: Trends in male carapace width distributions from core stations in the Div. 3K offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

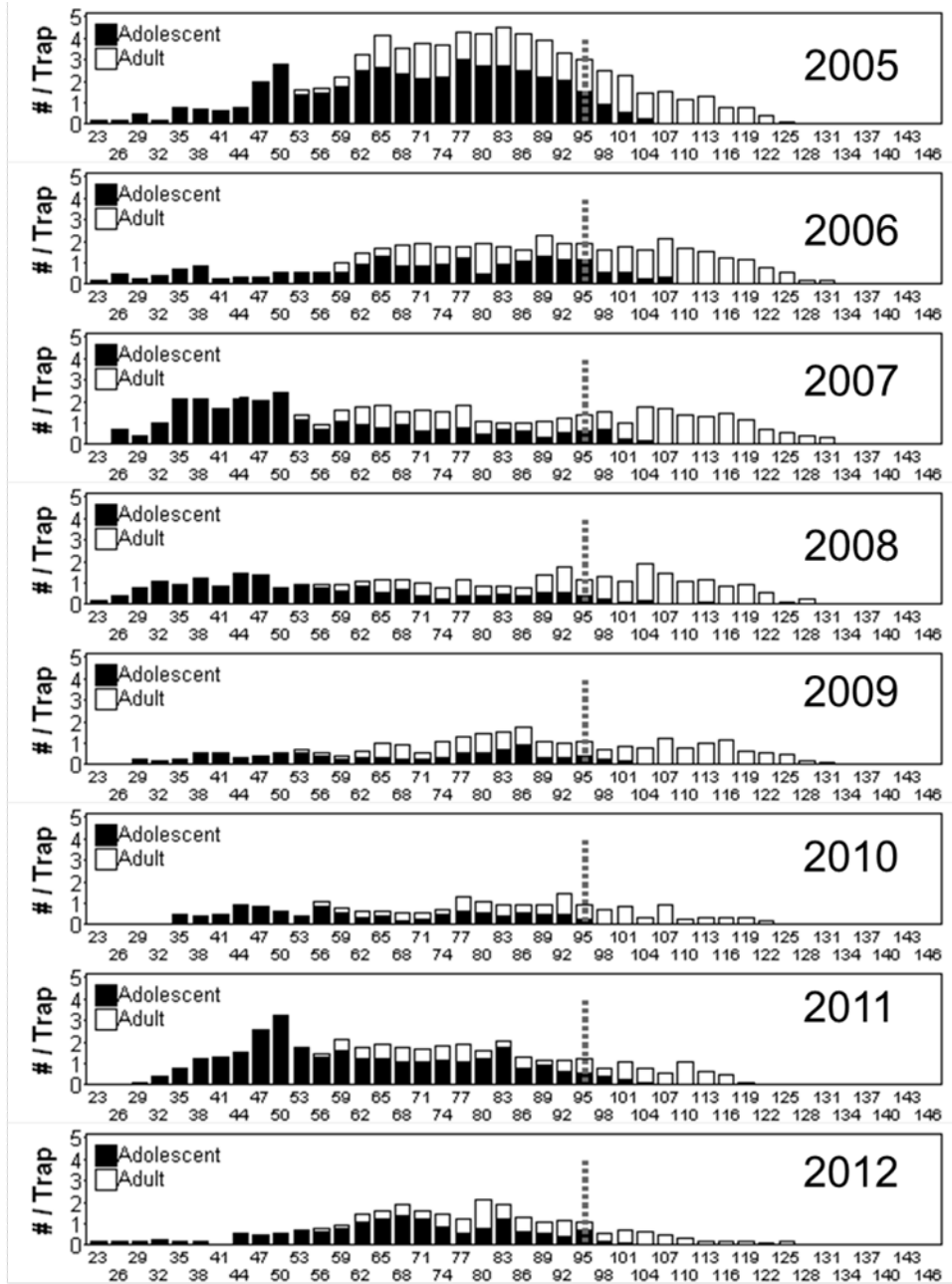


Figure 67: Trends in male carapace width distributions from small-mesh traps in the Div. 3K offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

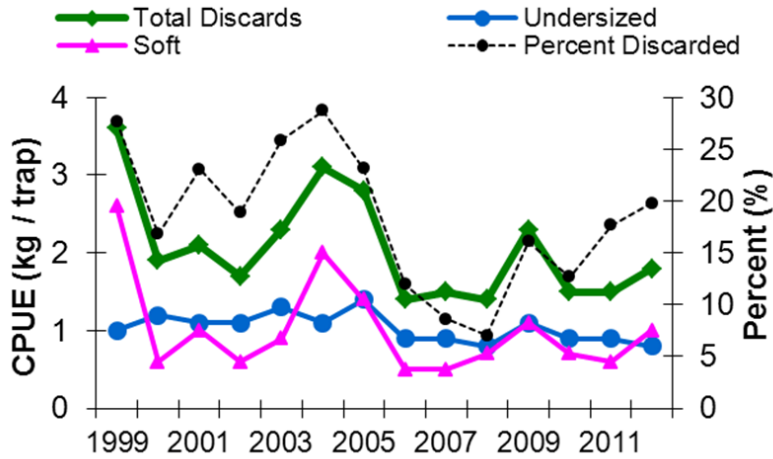


Figure 68: Trends in Division 3K offshore observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

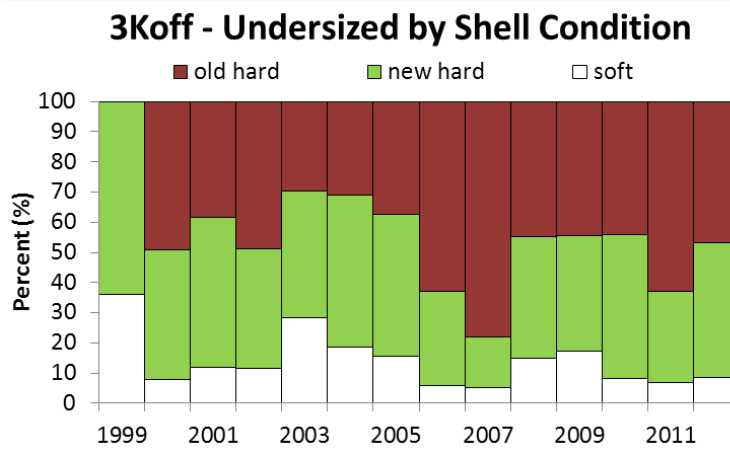


Figure 69: Trends in shell condition of 76-94mm CW crabs from Division 3K offshore observer sampling.

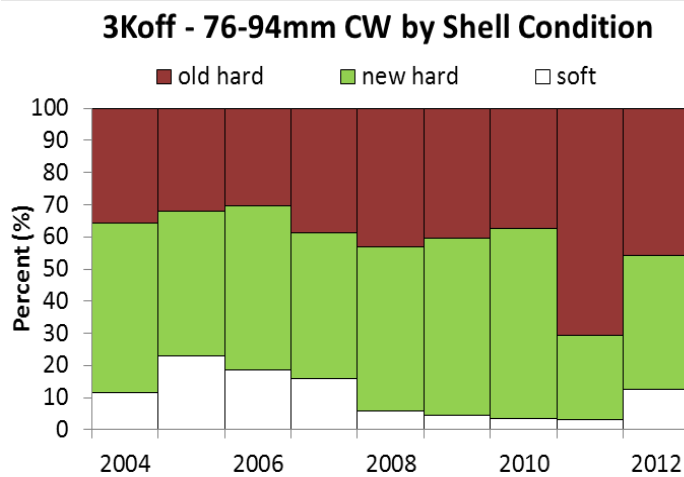


Figure 70: Trends in shell condition of 76-94mm CW crabs from Division 3K offshore CPS trap survey,

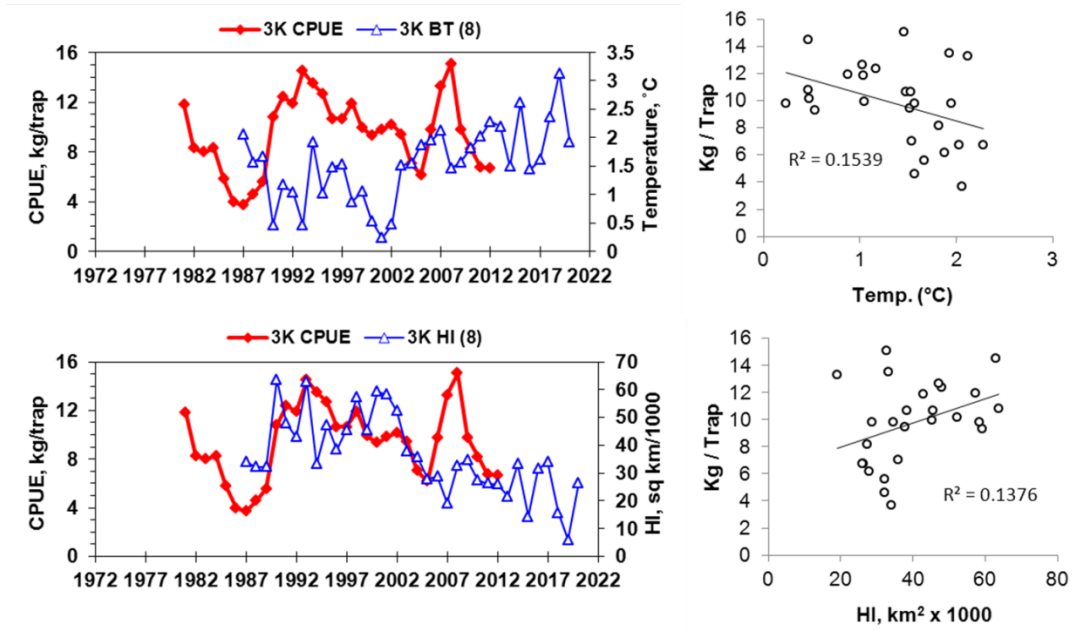


Figure 71: Trends in the Div. 3K offshore CPUE vs. bottom temperature (above) and spatial extent of <2 degree water (below) at an eight year lag (left), with corresponding scatter plots (right).

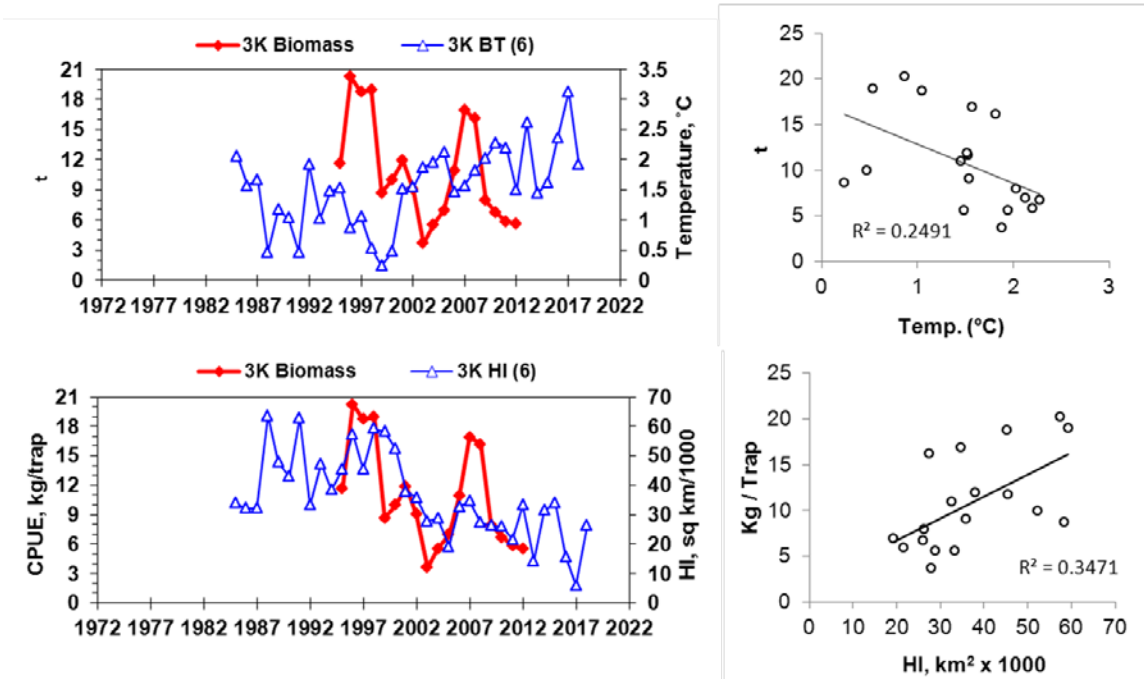


Figure 72: Trends in the Div. 3K offshore exploitable biomass index vs. bottom temperature (above) and spatial extent of <2 degree water (below) at a six year lag (left), with corresponding scatter plots (right).

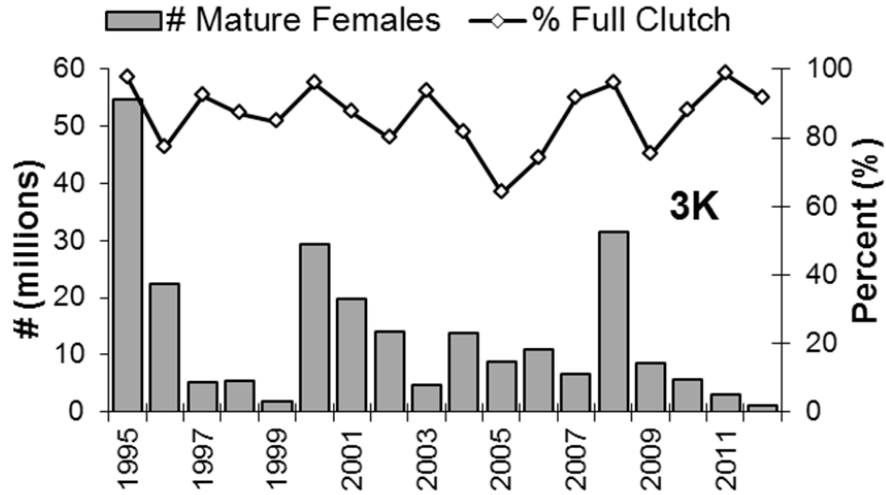


Figure 73: Trends in abundance of mature females as well as the percentage of mature females bearing full clutches of viable eggs in Div. 3K from fall multi-species surveys.

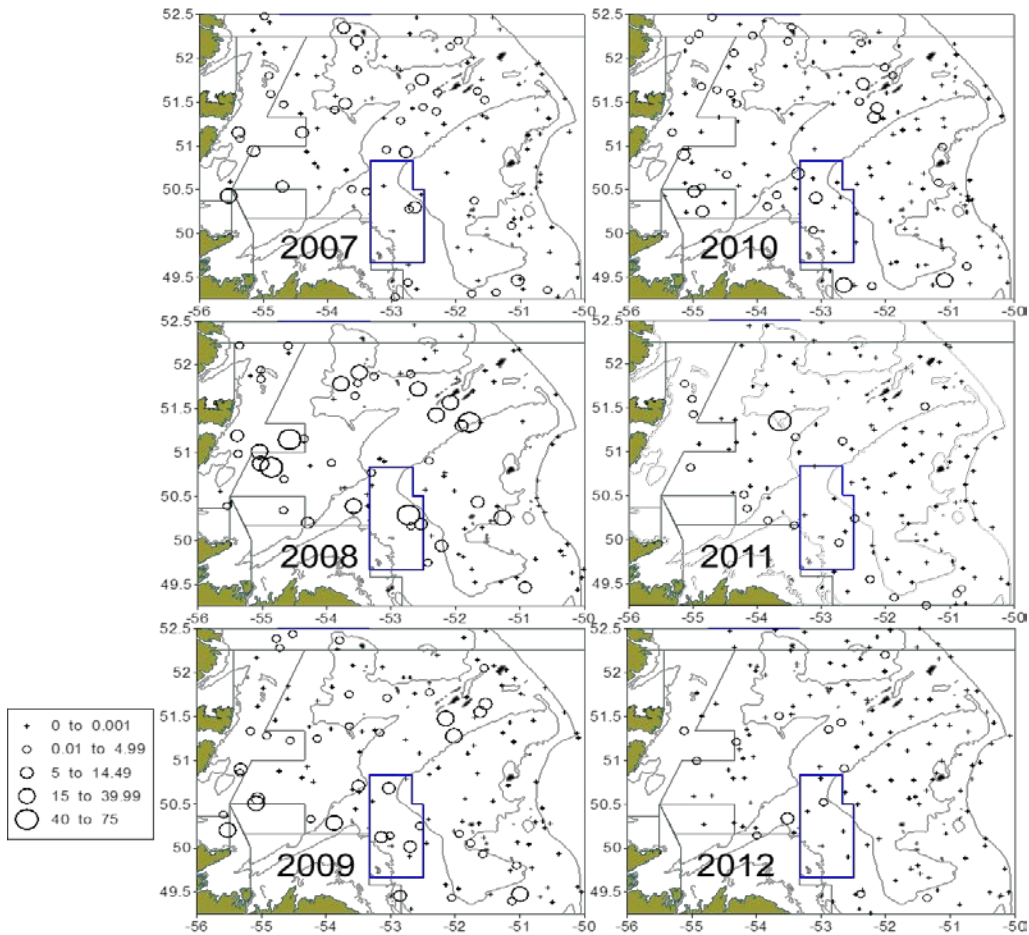


Figure 74: Spatial distribution of catches (number / set) of mature females in the Div. 3K offshore fall trawl survey.

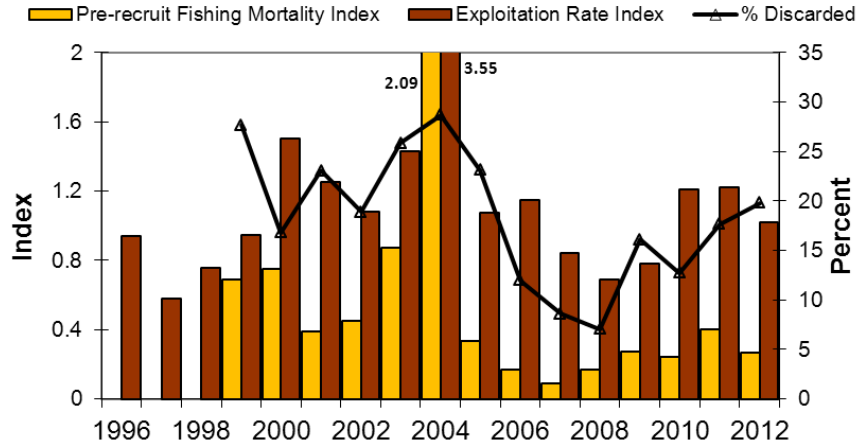


Figure 75: Trends in Div. 3K offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality rate index) and in the percentage of the catch discarded in the fishery.

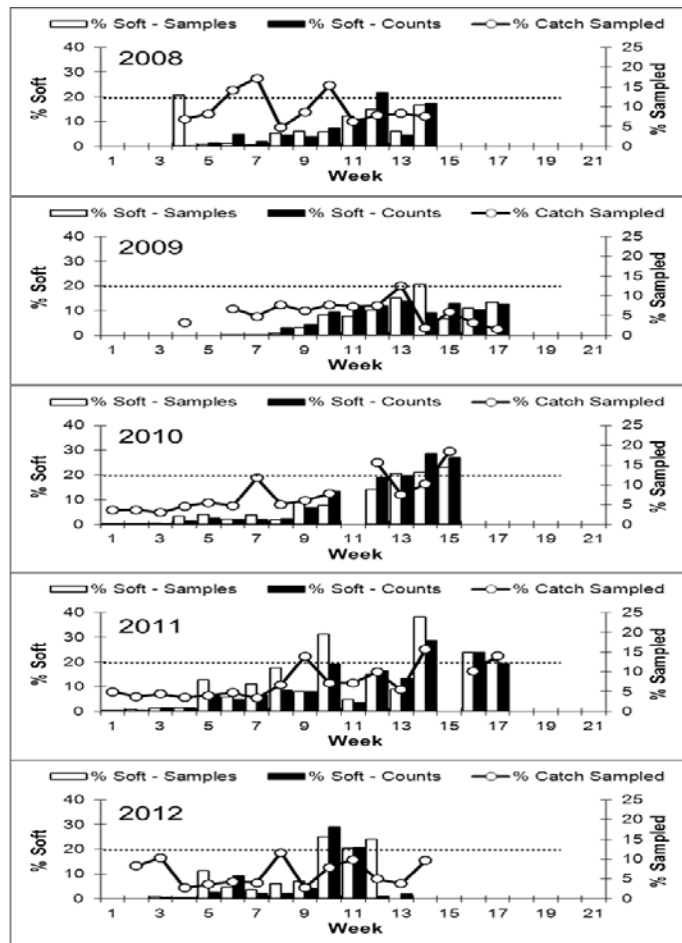


Figure 76: Trends in weekly percentages of soft-shell crab from observer at-sea sampling in Div. 3K offshore.

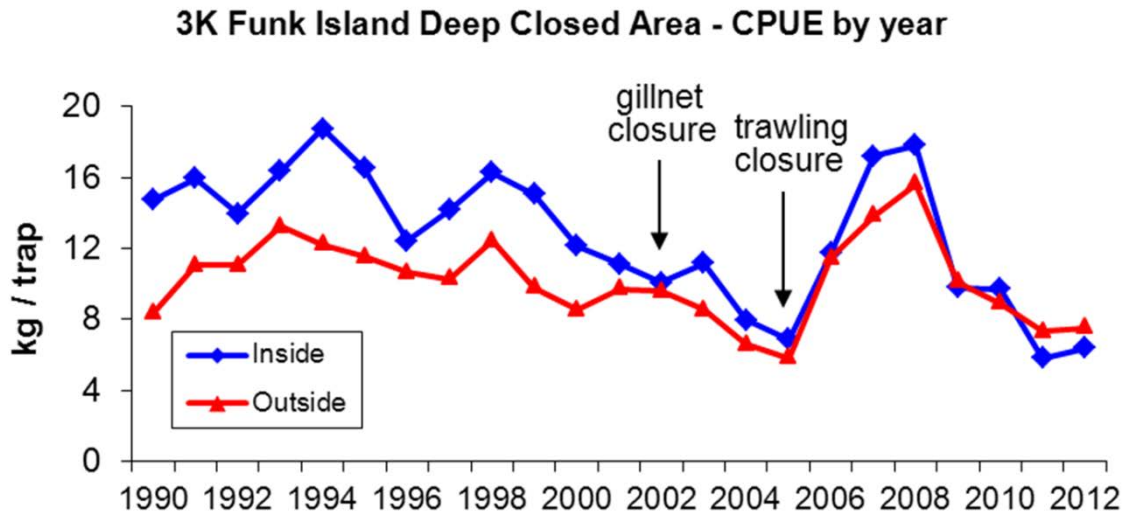


Figure 77: Div. 3K offshore commercial CPUE inside vs. outside the Funk Island Deep closed area.

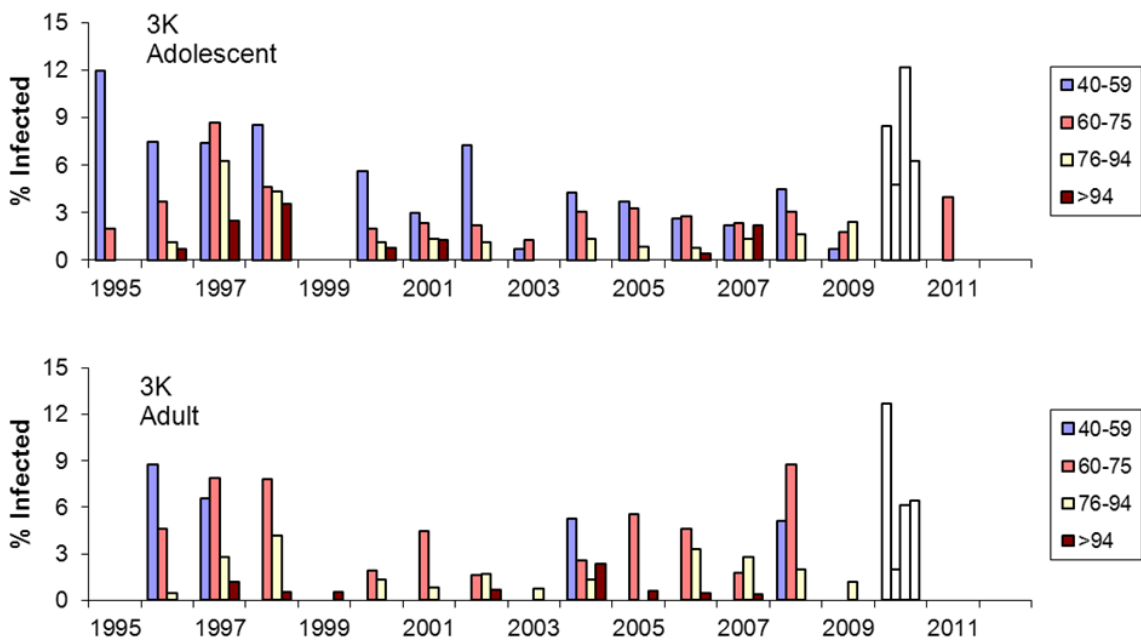


Figure 78: Annual trends in prevalence of BCD in new-shelled adolescents (above) and adult (below) males by size group from Div. 3K fall trawl surveys. The 2010 data are anomalous due to Technician error.

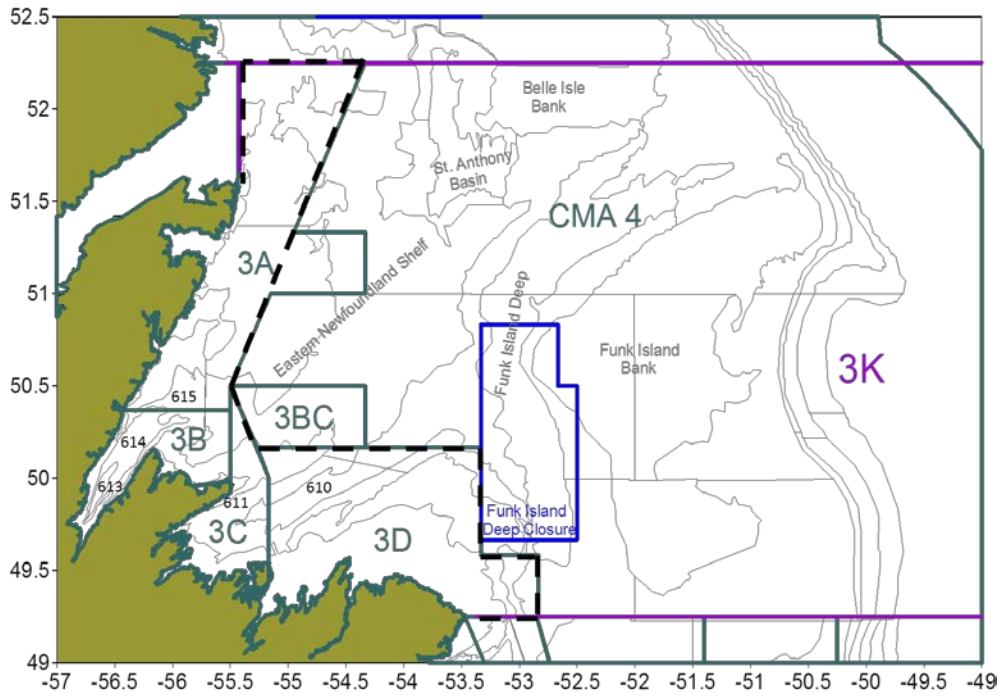


Figure 79: Map of Division 3K showing crab management areas and important bathymetric features as well as the Funk Island Deep closed area (blue box). Dashed perimeter indicates inshore areas.

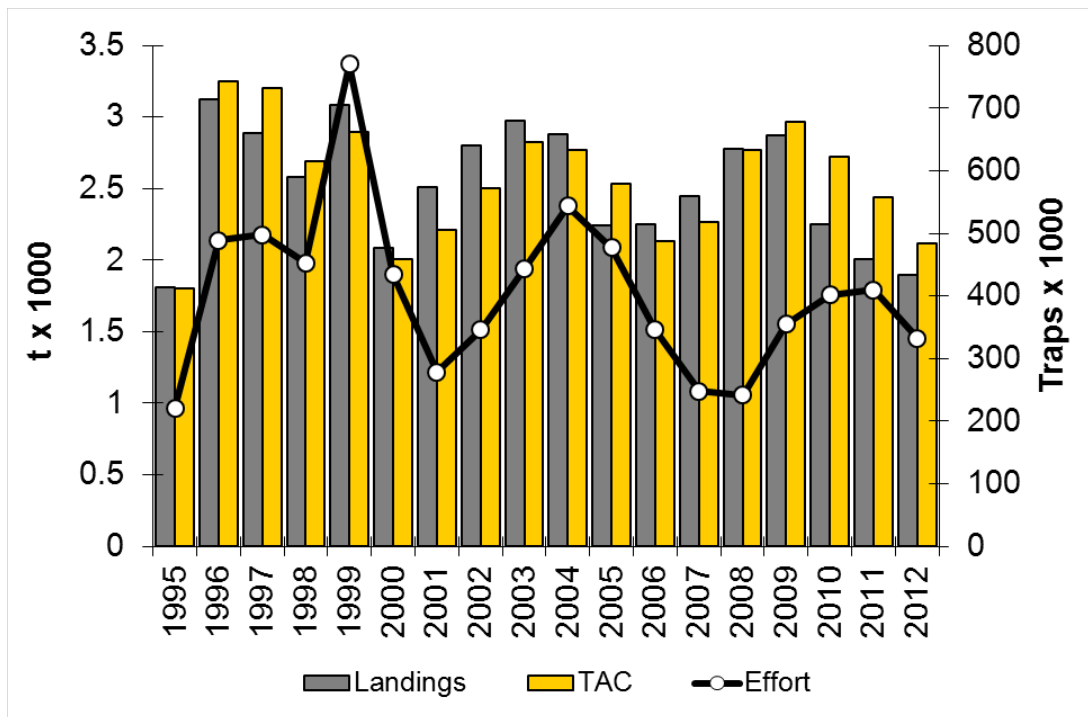


Figure 80: Trends in Div. 3K inshore landings, TAC, and fishing effort.

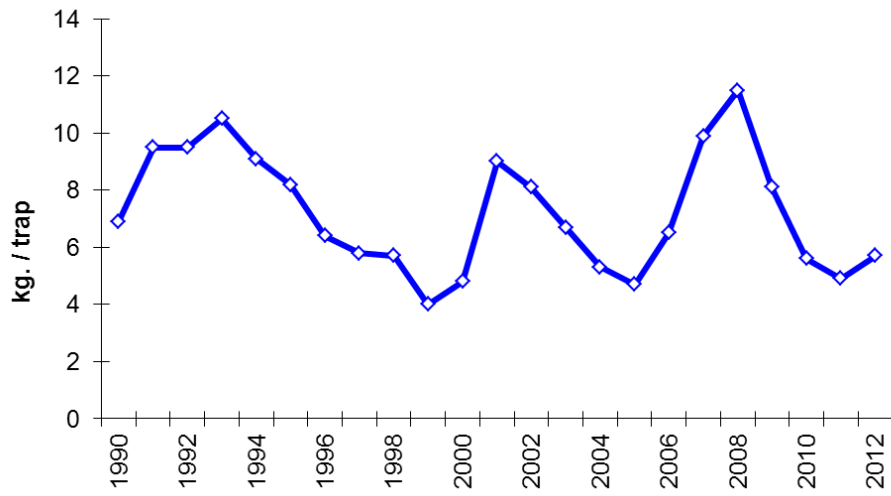


Figure 81: Trends in commercial logbook-based CPUE in the Div. 3K inshore fishery.

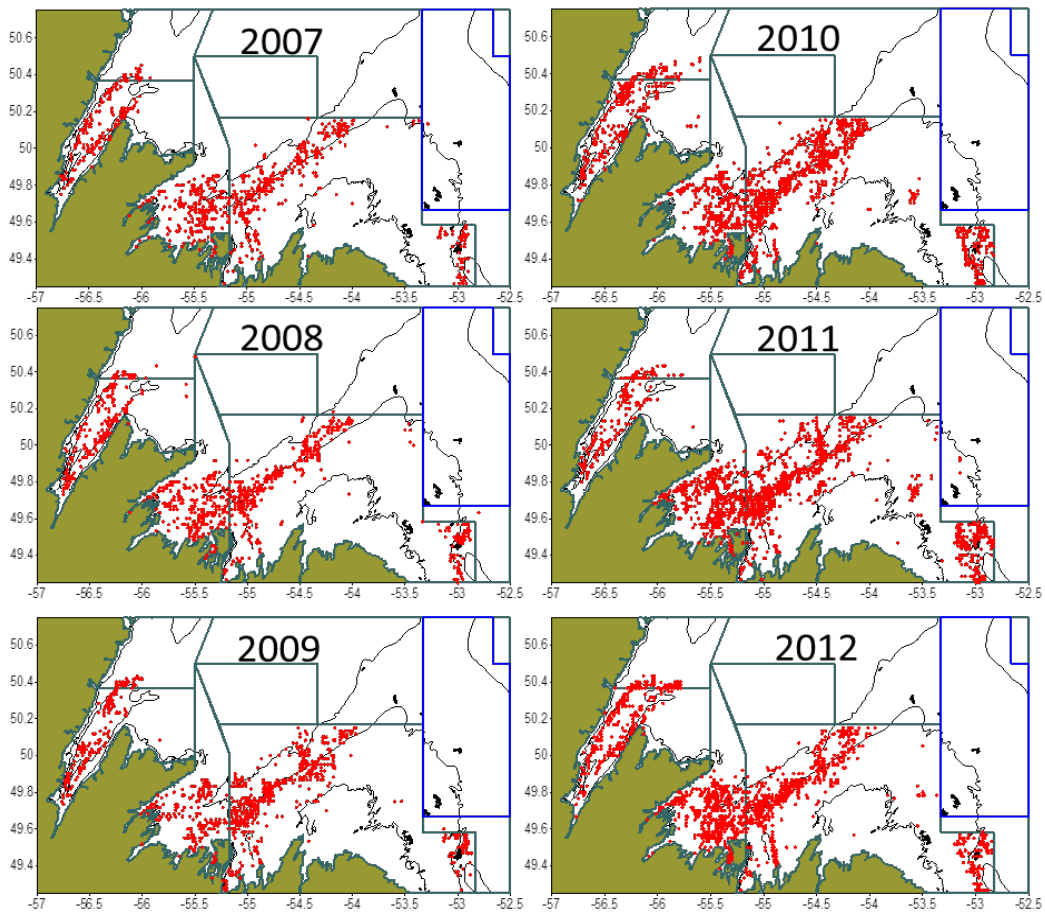


Figure 82: Spatial distribution of Div. 3K inshore fishing effort by year.

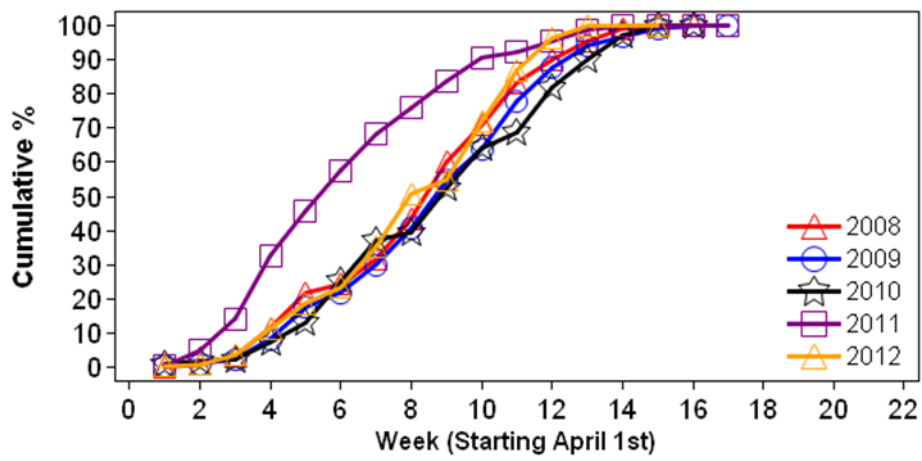


Figure 83: Seasonal trends in weekly fishing effort for Div. 3K inshore.

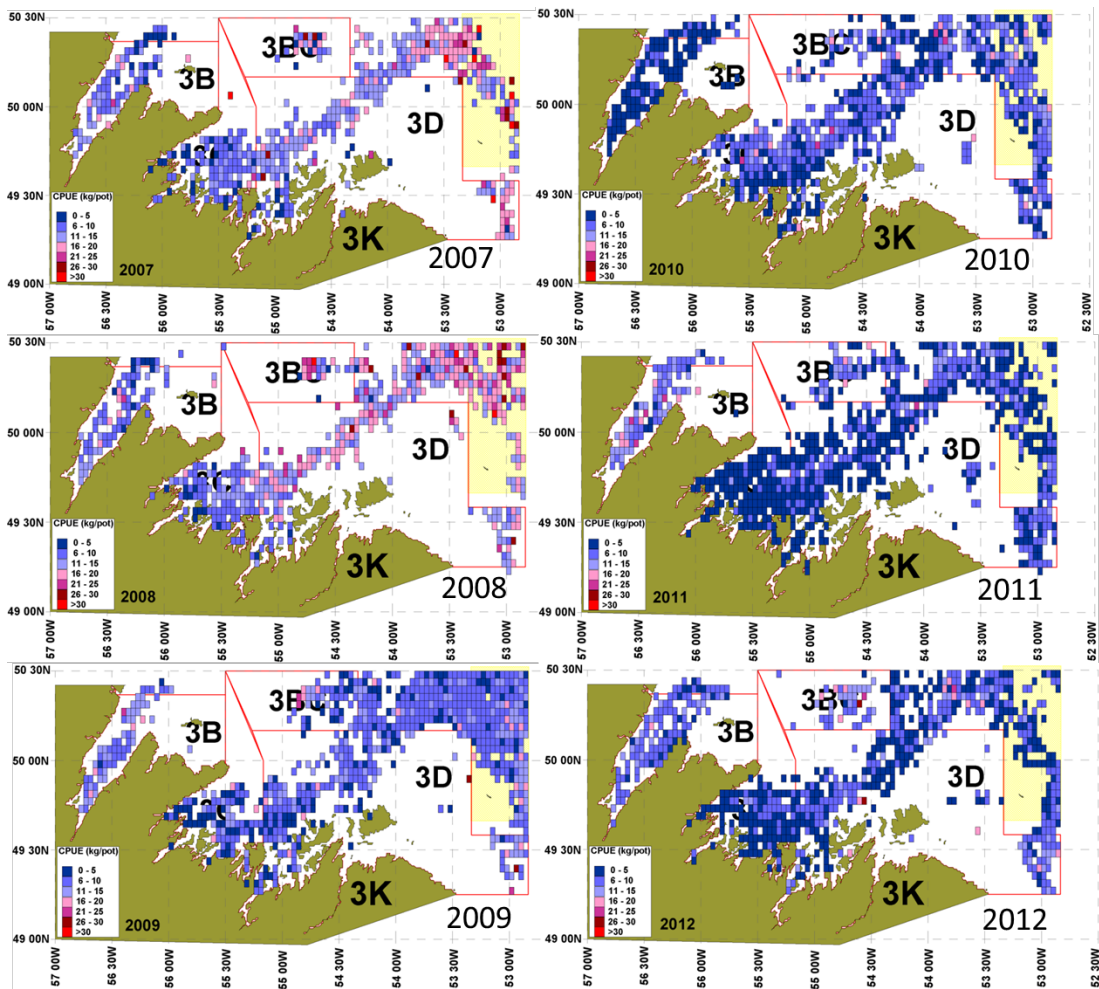


Figure 84: Spatial distribution of Div. 3K inshore logbook CPUE by year.

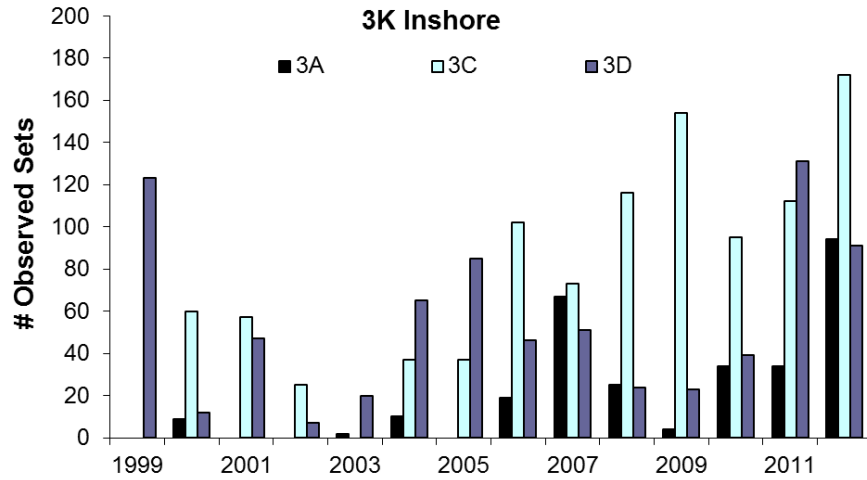


Figure 85: Trends in number of observed sets by Crab Management Areas and year in Division 3K inshore.

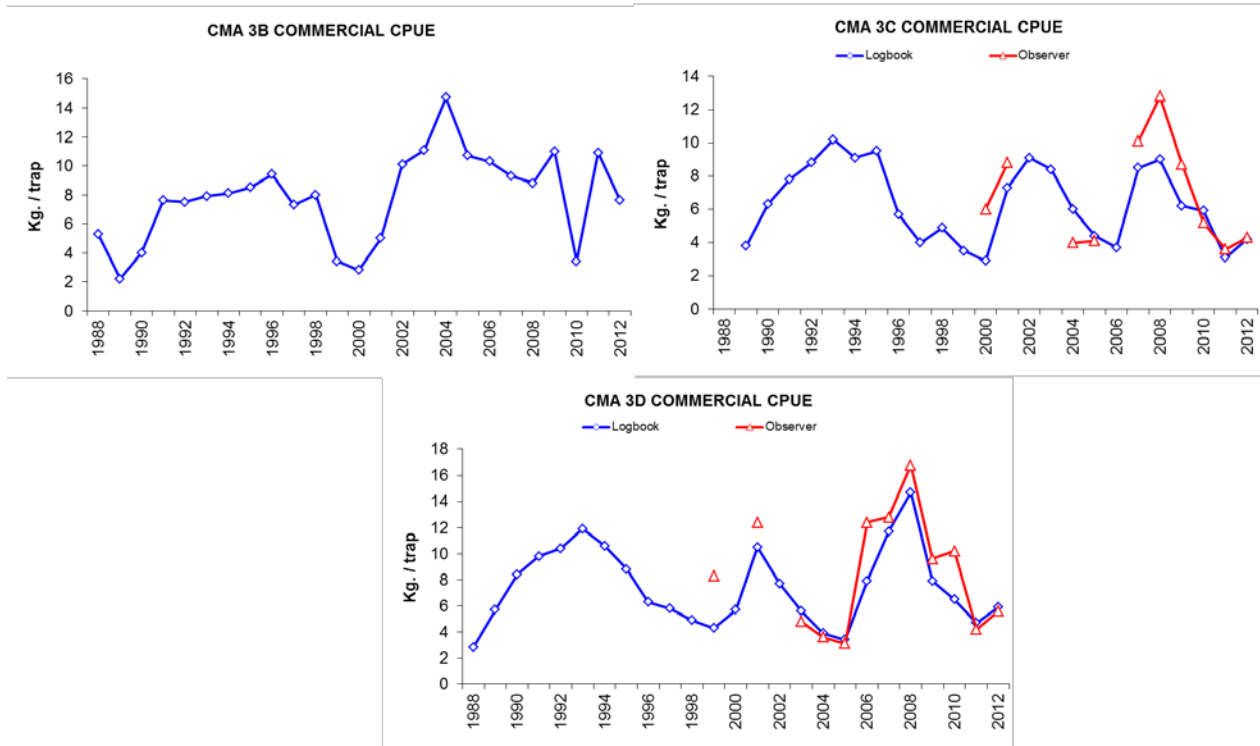


Figure 86: Trends in Division 3K inshore logbook CPUE and observer CPUE by Crab Management Area.

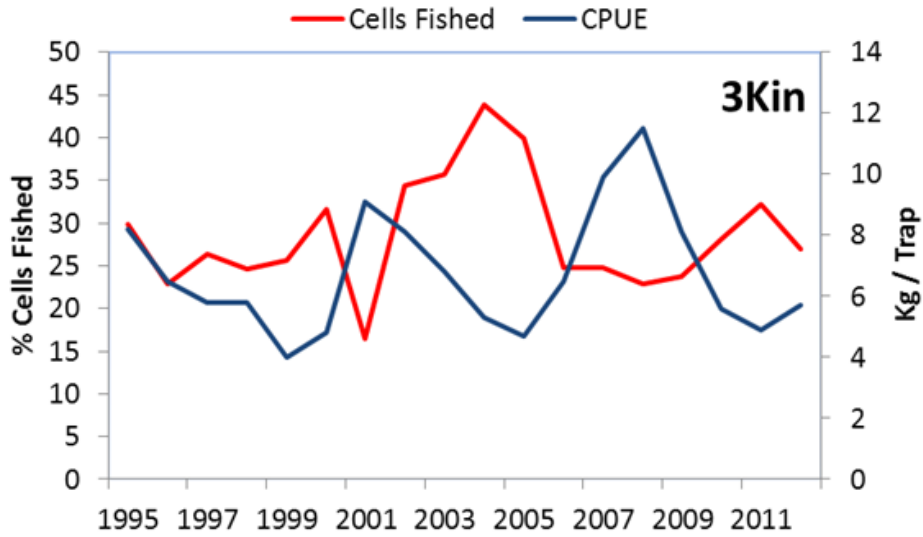


Figure 87: Trends in Div. 3K inshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

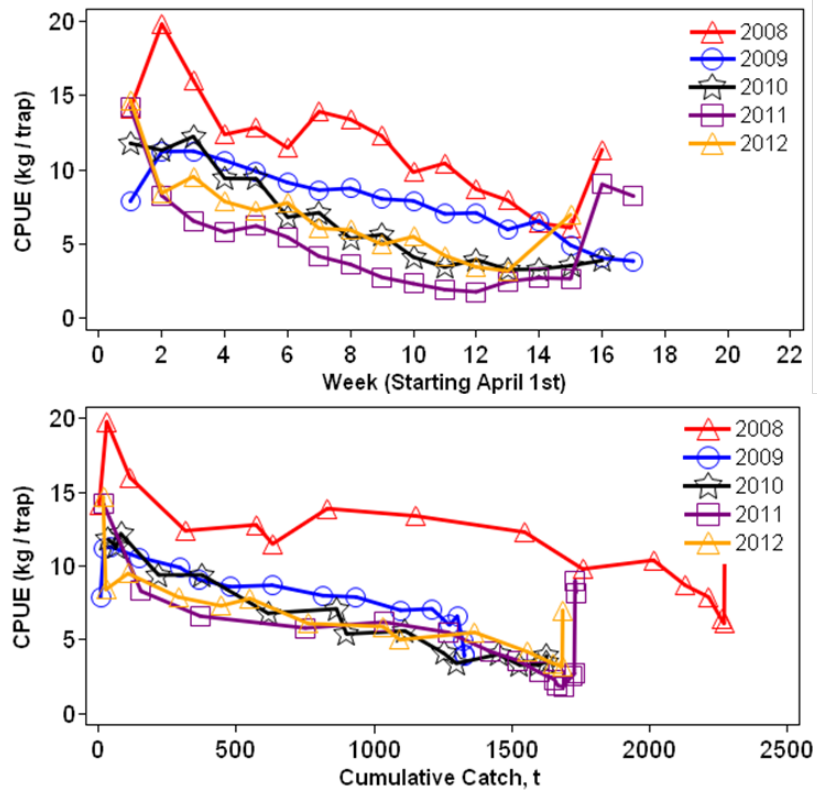


Figure 88: Seasonal trends in logbook-based CPUE for Div. 3K inshore; by week (above), and in relation to cumulative catch (below).

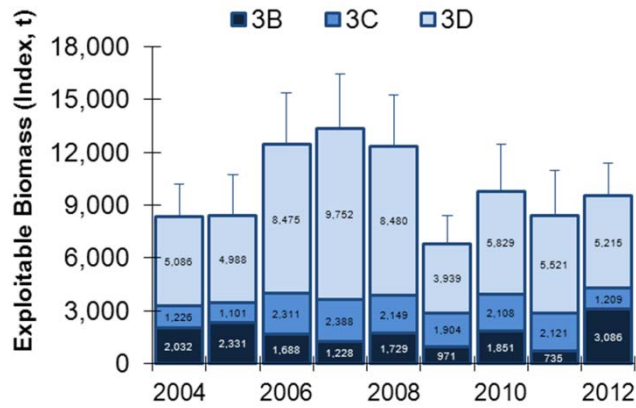


Figure 89: Exploitable biomass indices by management area from the CPS trap survey in Div. 3K inshore.

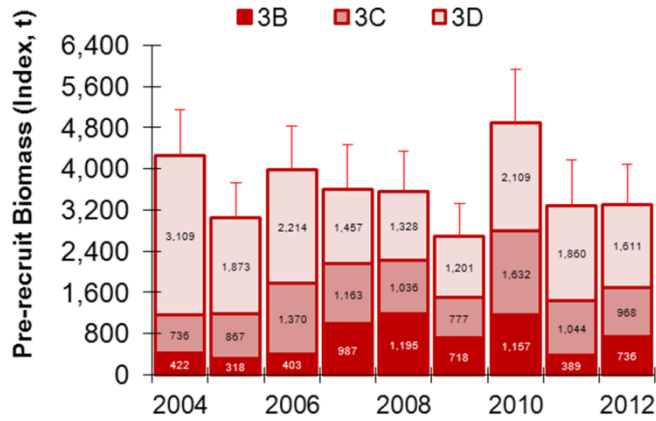


Figure 90: Pre-recruit biomass indices by management area from the CPS trap survey in Div. 3K inshore.

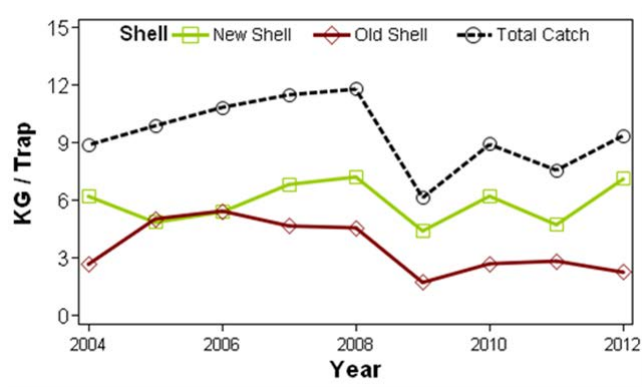


Figure 91: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in Div. 3K inshore.

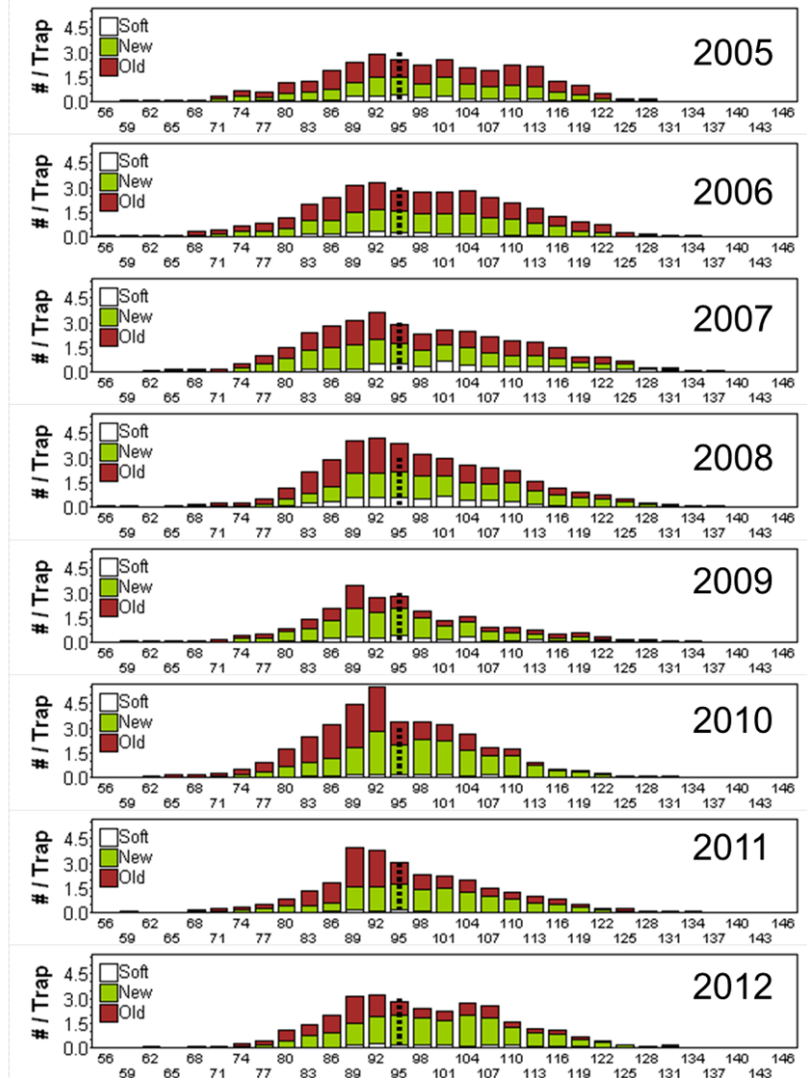


Figure 92: Trends in male carapace width distributions from core stations in the Div. 3K inshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

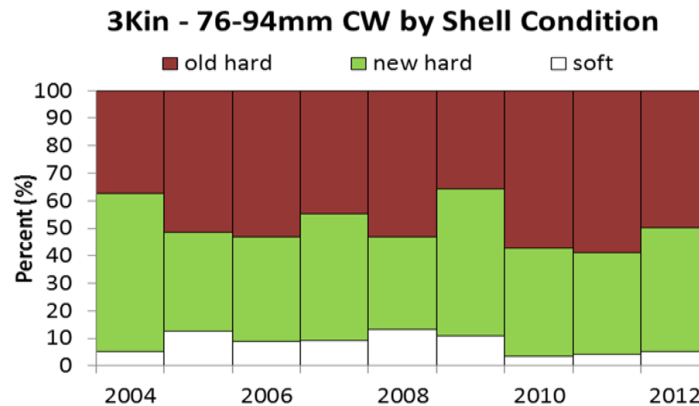


Figure 93: Trends in shell condition of 76-94mm CW crabs from the Div. 3K inshore CPS trap survey.

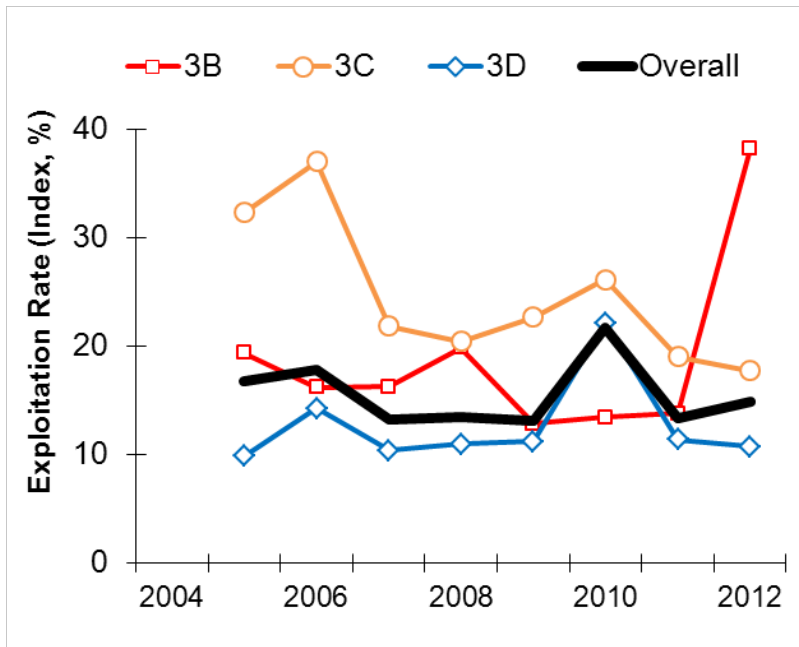


Figure 94: Exploitation rate indices by crab management area as well as overall for Div. 3K inshore based on the CPS trap survey.

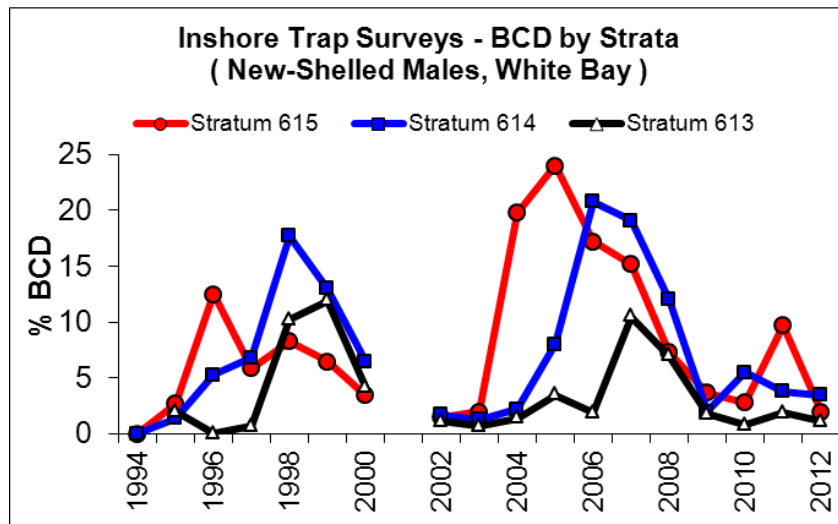


Figure 95: Prevalence of BCD in new-shelled males from Div. 3K DFO inshore trap surveys by stratum in White Bay.

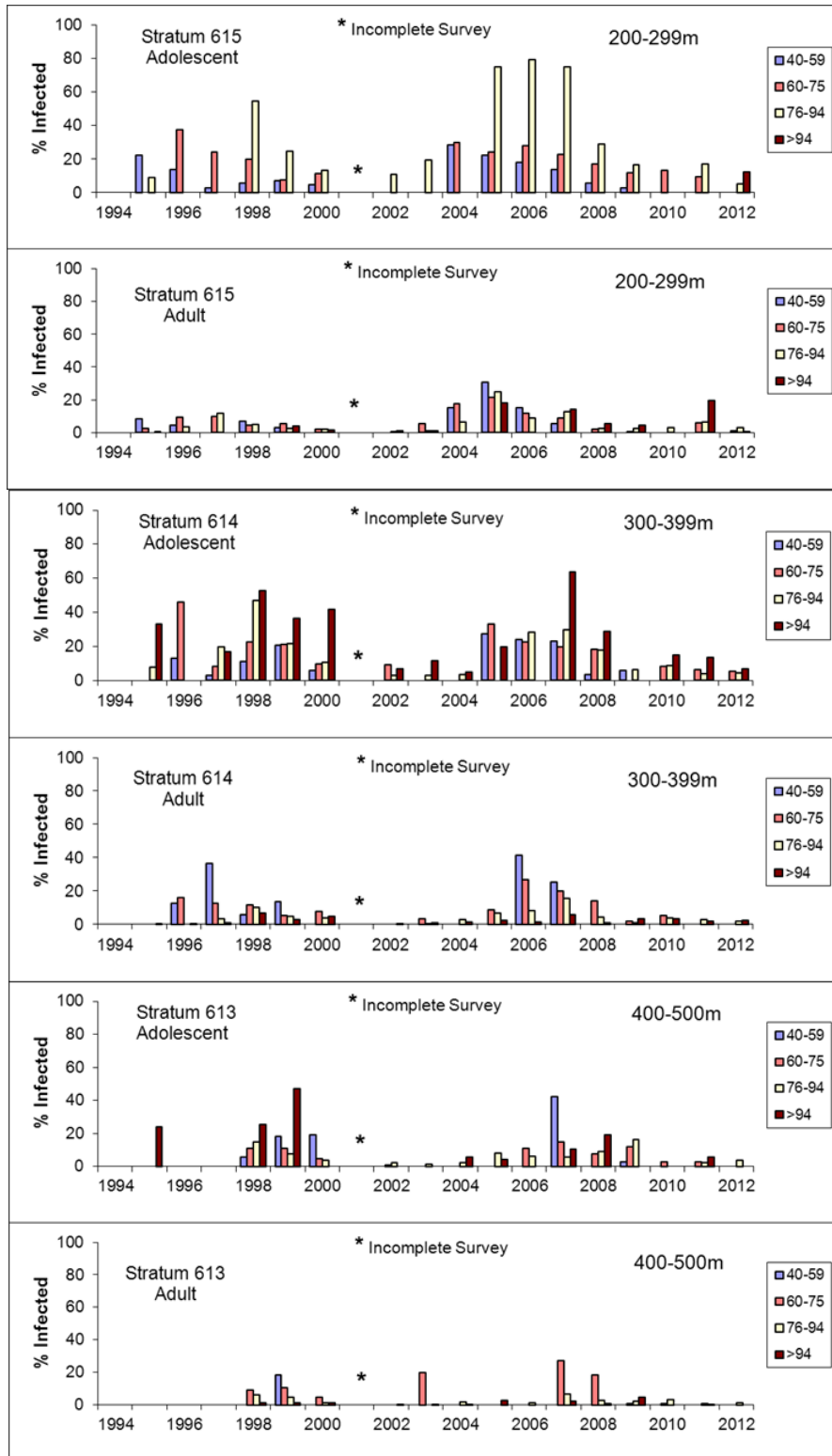


Figure 96: Annual trends in prevalence of BCD in new-shelled males by stratum, year and size group from DFO trap surveys in White Bay; adolescents (above) and adults (below).

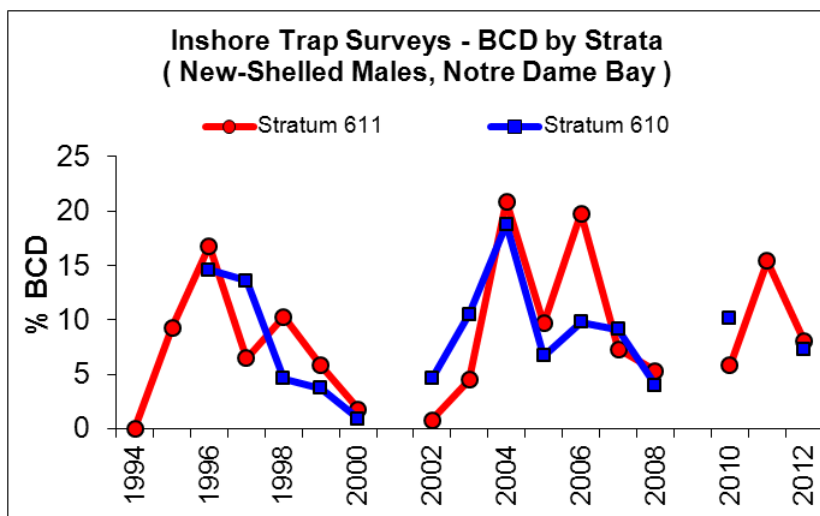


Figure 97: Prevalence of BCD in new-shelled males from Div. 3K DFO inshore trap surveys by stratum in Notre Dame Bay.

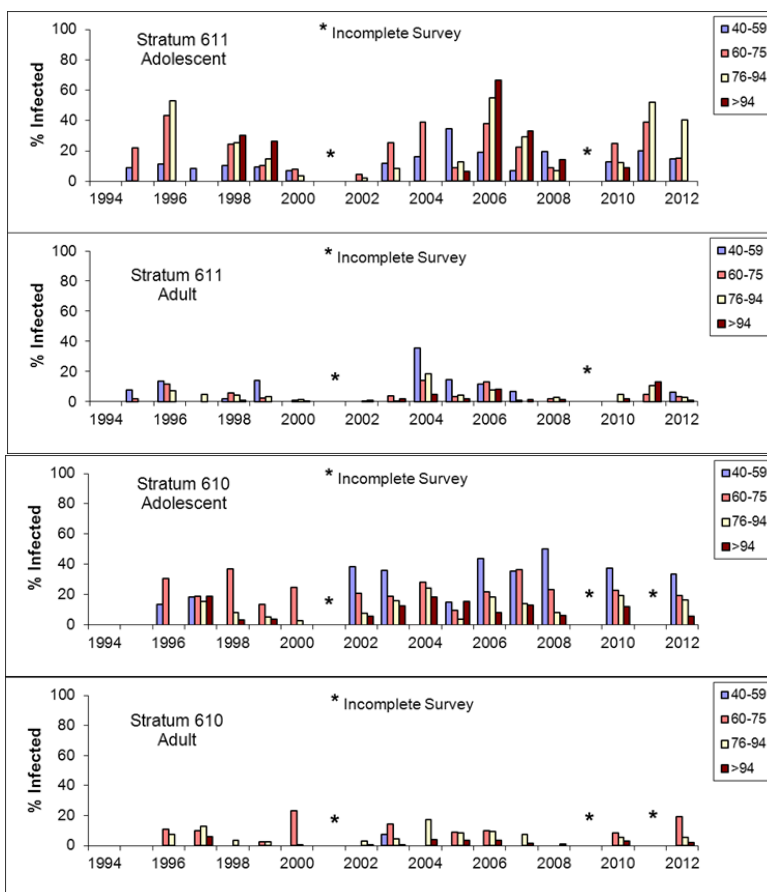


Figure 98: Trends of prevalence of BCD in new-shelled males by stratum, year and size group from DFO trap surveys in Notre Dame Bay; adolescents (above) and adults (below).

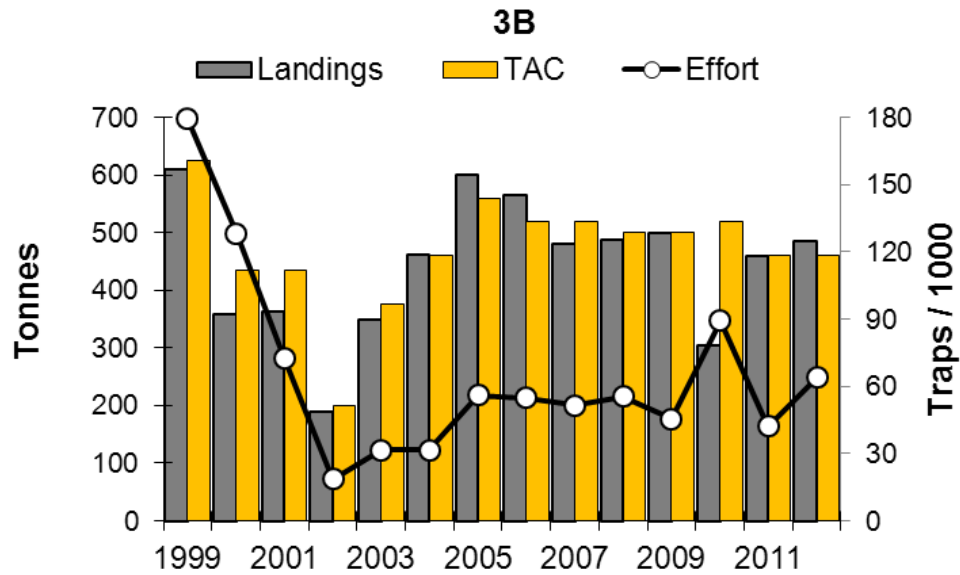


Figure 99: Trends in CMA 3B landings, TAC, and fishing effort.

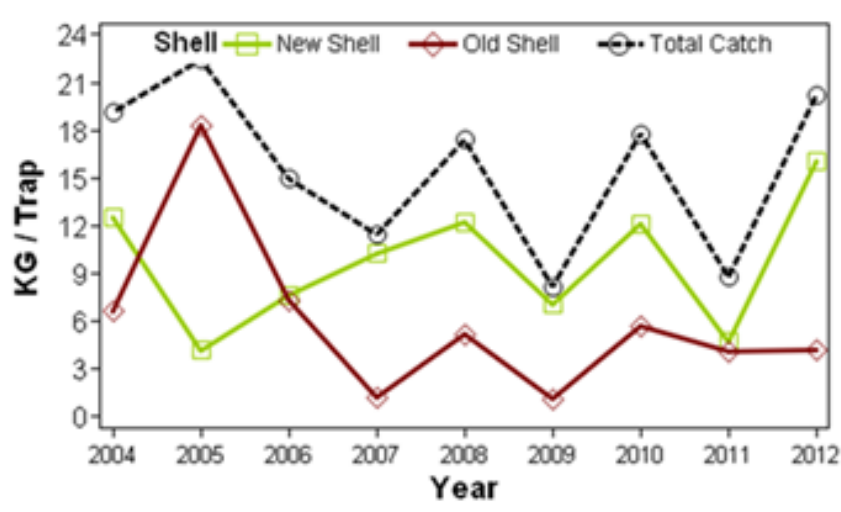


Figure 100: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 3B.

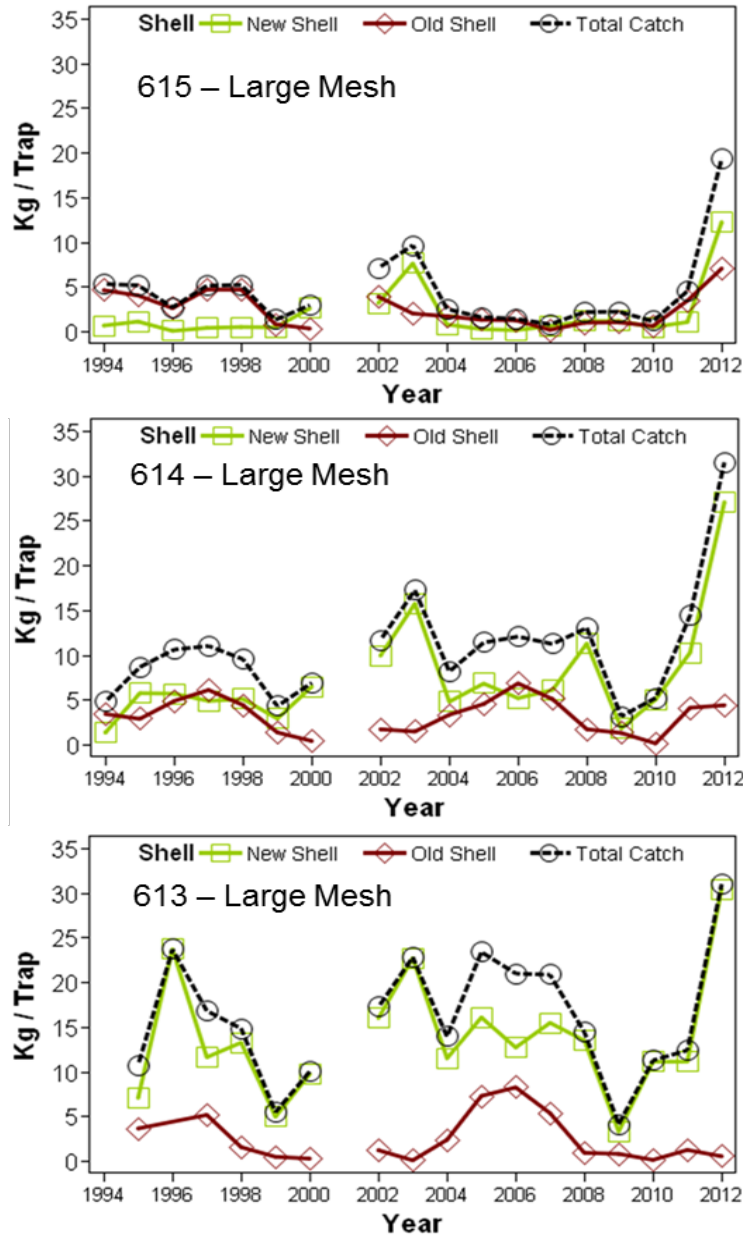


Figure 101: Trends in CPUE by shell condition for legal-sized crabs from strata occupied in the DFO trap survey in White Bay. No survey was conducted in 2001.

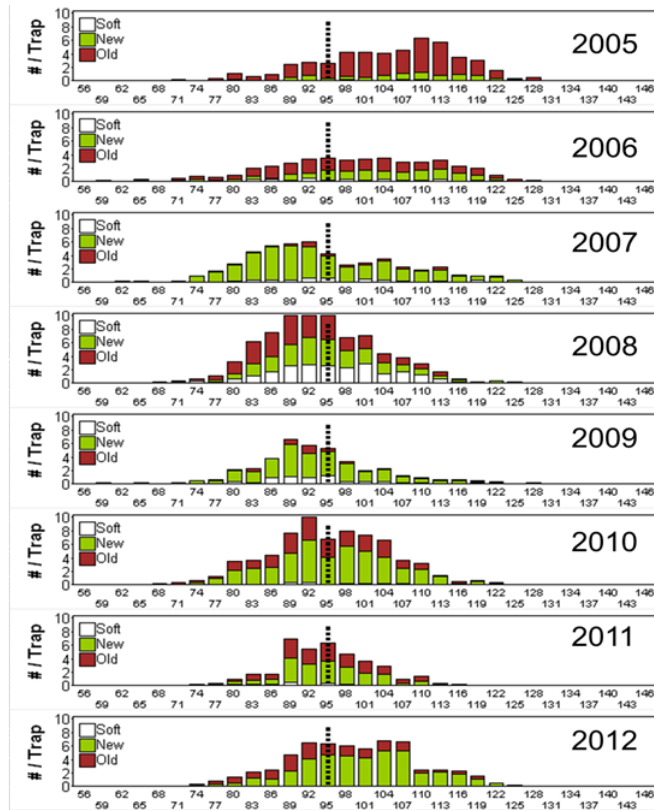


Figure 102: Trends in male carapace width distributions from core stations in CMA 3B from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

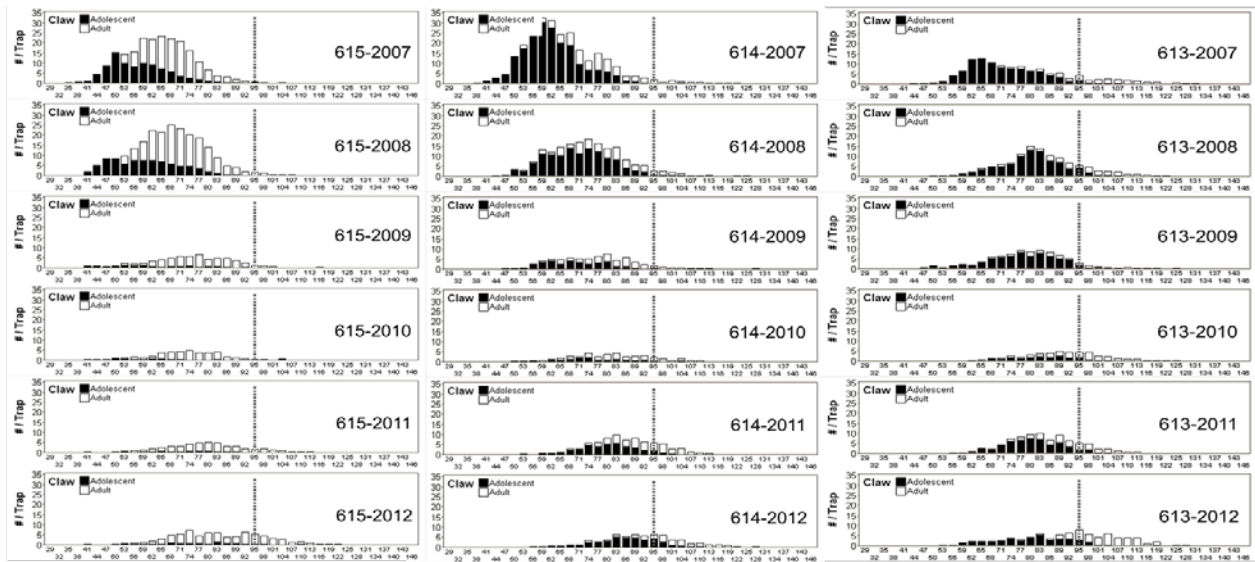


Figure 103: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in the DFO trap survey in White Bay. The vertical dashed line indicates the minimum legal size.

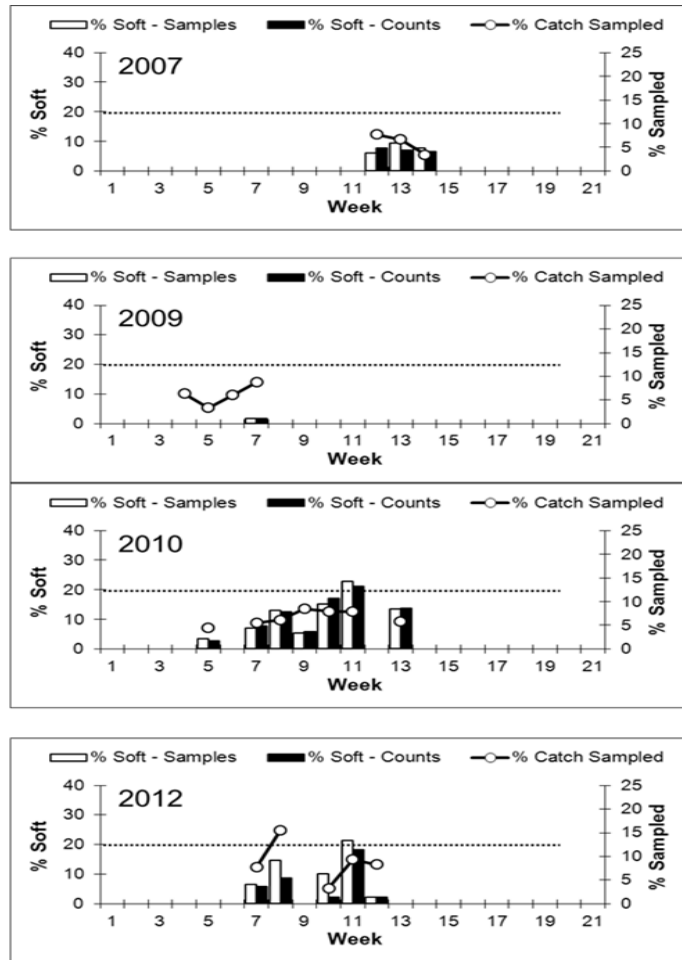


Figure 104: Trends in weekly percentages of soft-shell crab in CMA 3B from at-sea sampling by observers.

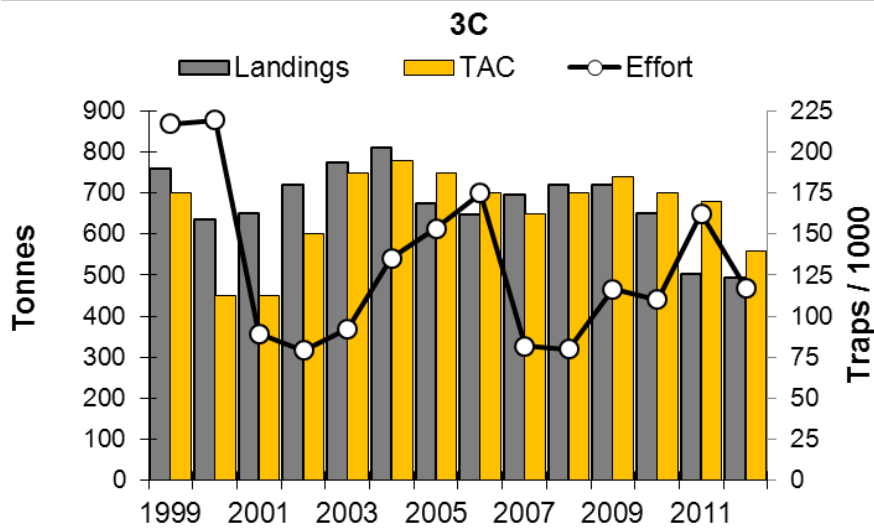


Figure 105: Trends in CMA 3C landings, TAC, and fishing effort.

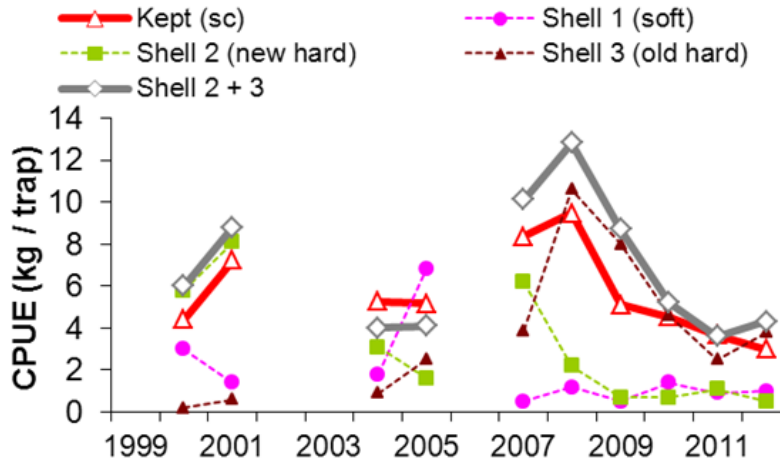


Figure 106: Trends in CMA 3C observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

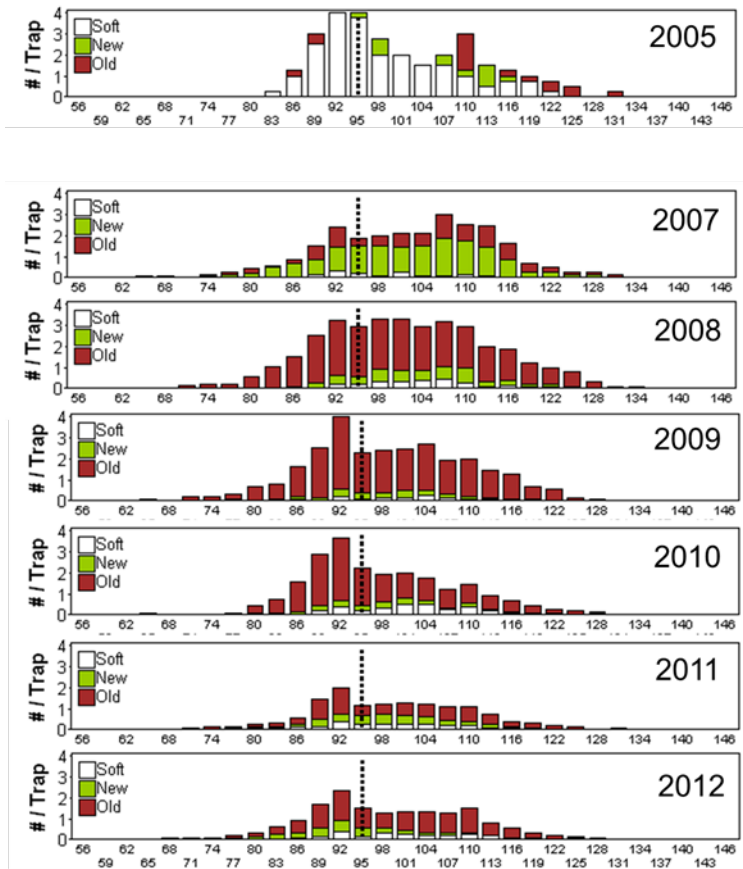


Figure 107: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 3C. The vertical dashed line indicates the minimum legal size.

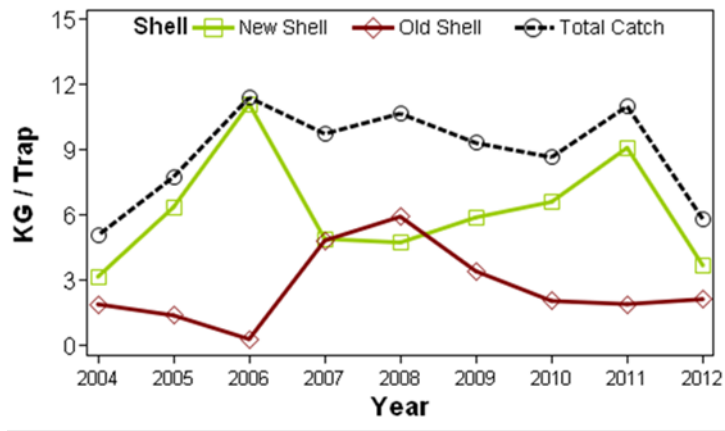


Figure 108: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 3C.

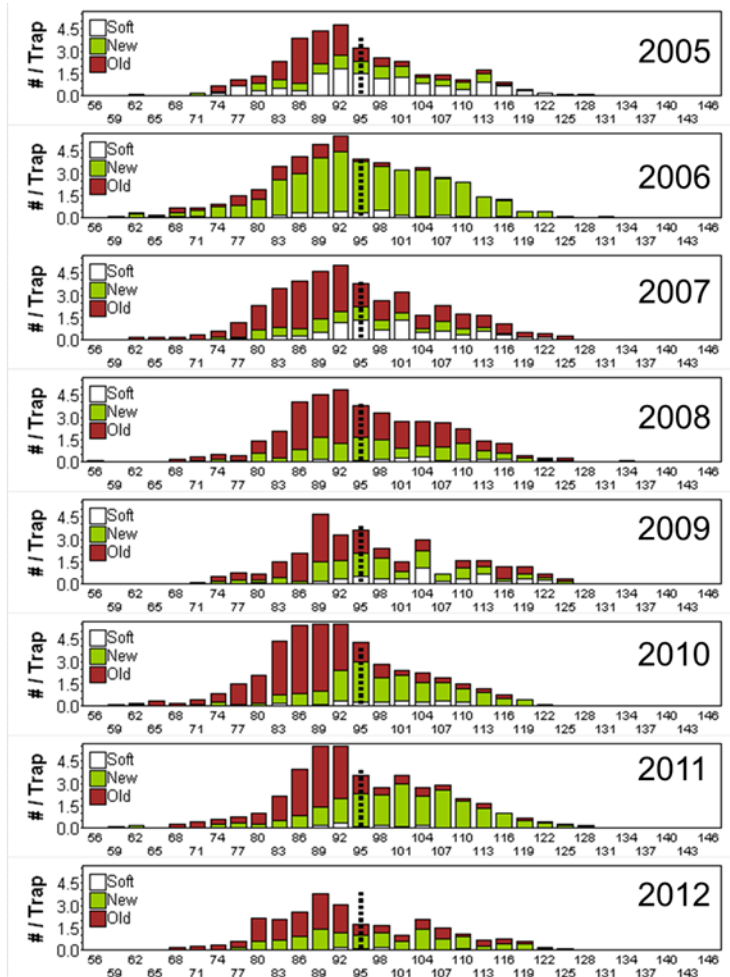


Figure 109: Trends in male carapace width distributions from core stations in CMA 3C from the CPS survey. The vertical dashed line indicates the minimum legal size.

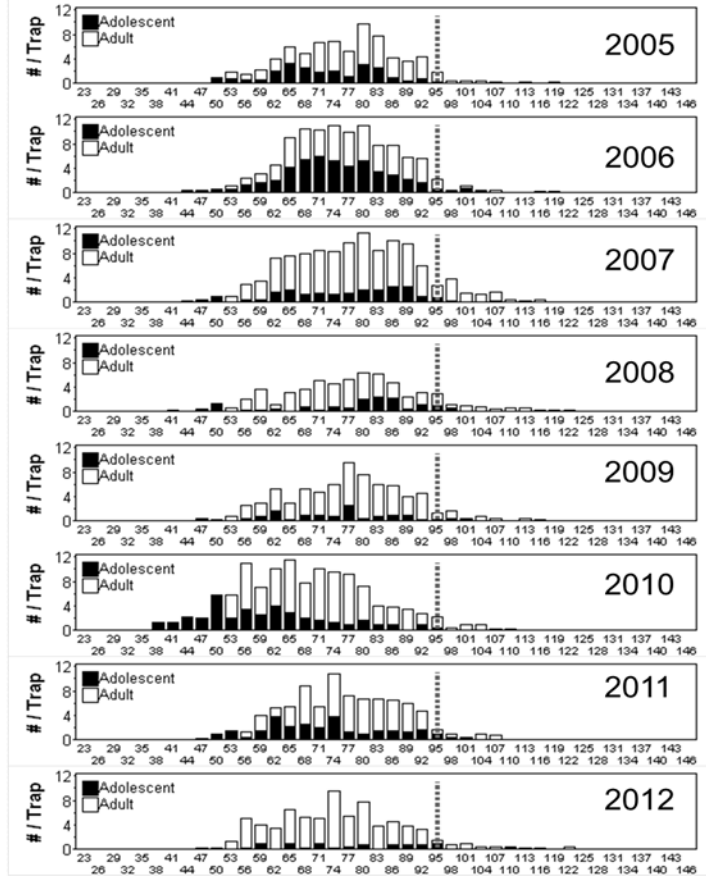


Figure 110: Trends in male carapace width distributions from small-mesh traps in CMA 3C from the CPS survey. The vertical dashed line indicates the minimum legal size.

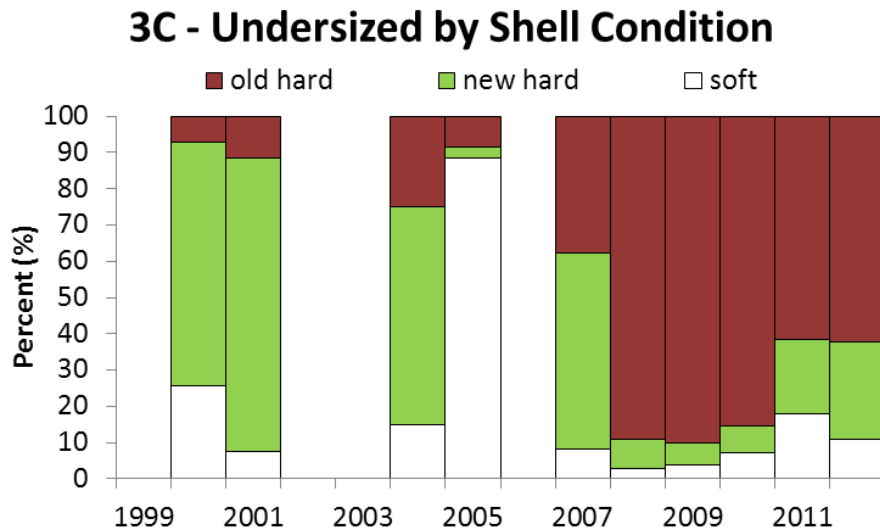


Figure 111: Trends in shell condition of 76-94mm CW crabs from CMA 3C observer sampling.

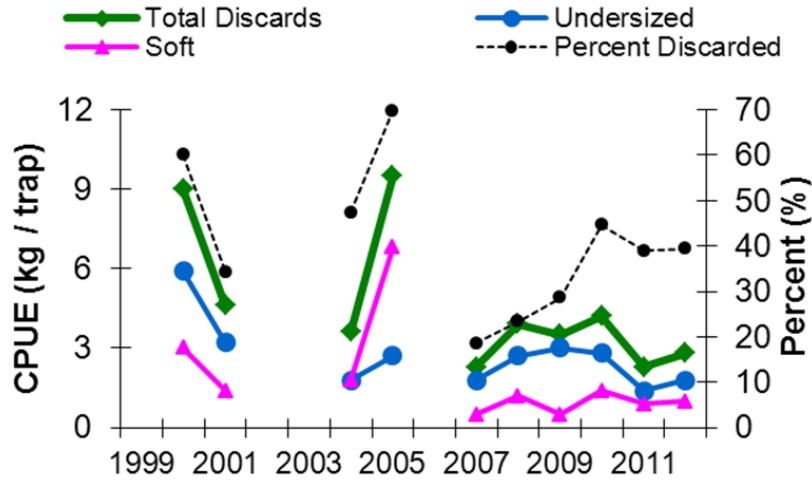


Figure 112: Trends in CMA 3C observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

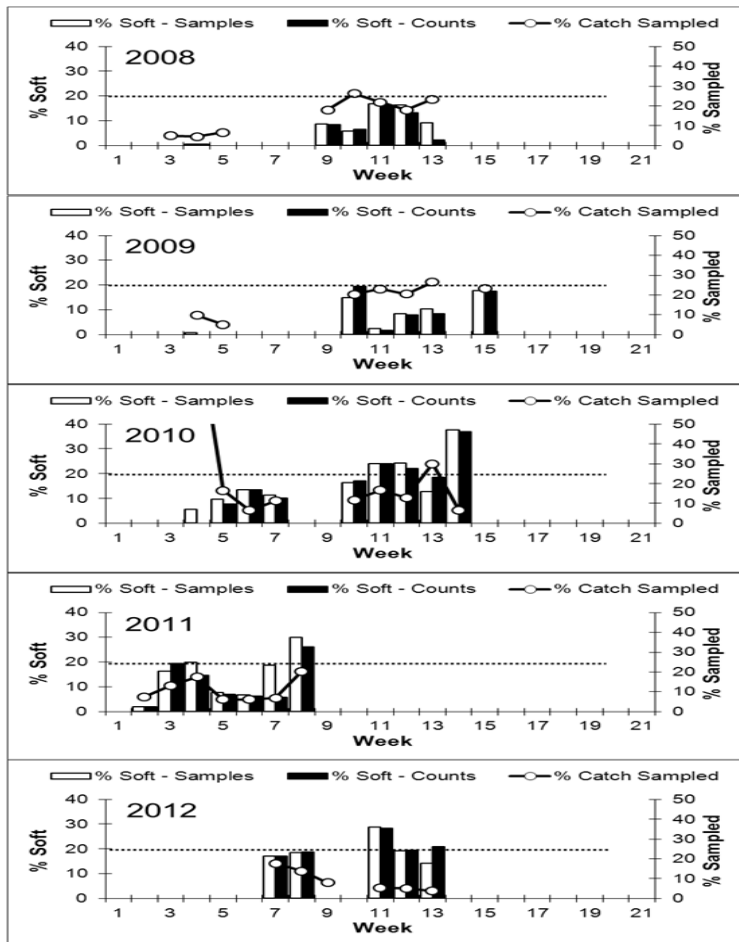


Figure 113: Trends in weekly percentages of soft-shell crab in CMA 3C from at-sea sampling by observers.

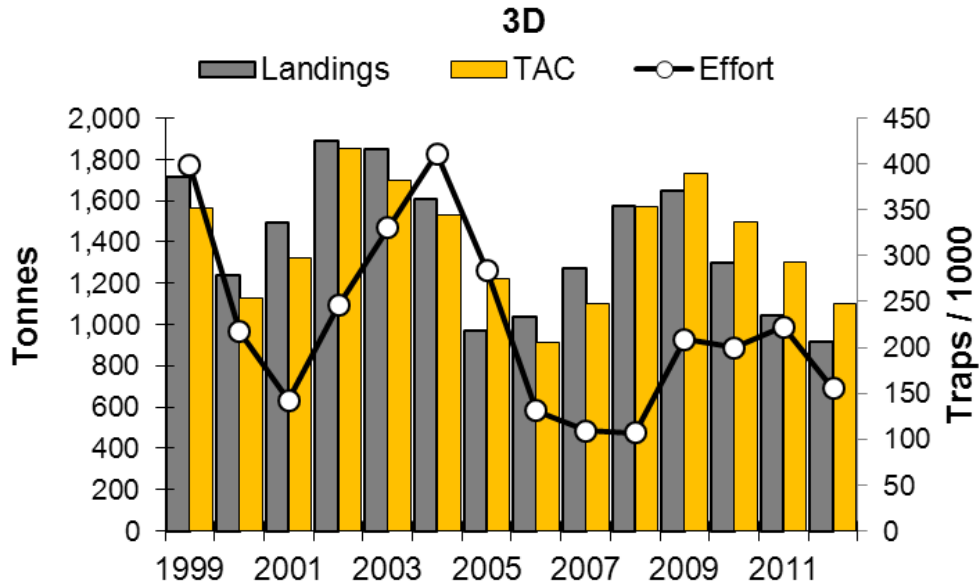


Figure 114: Trends in CMA 3D landings, TAC, and fishing effort.

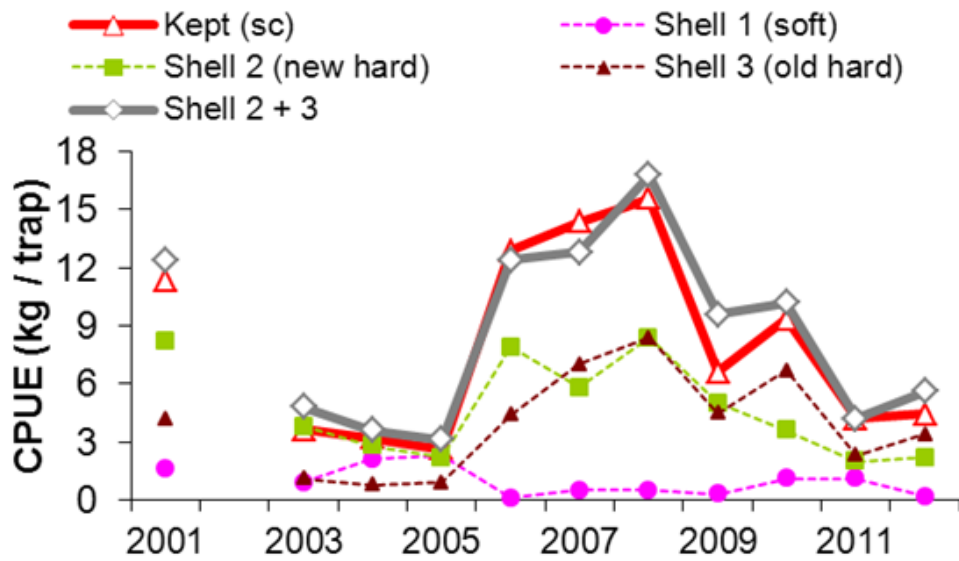


Figure 115: Trends in CMA 3D observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

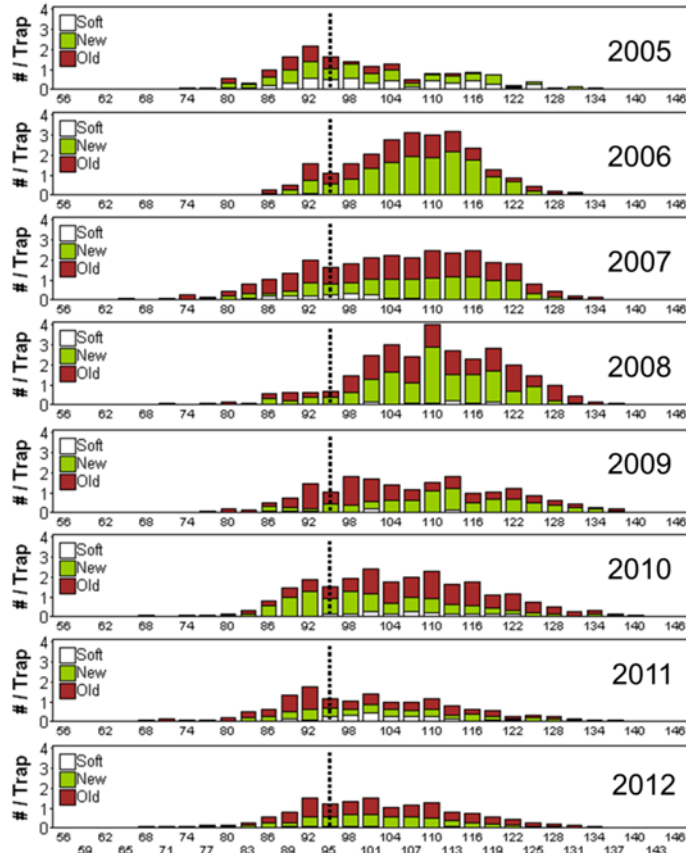


Figure 116: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 3D. The vertical dashed line indicates the minimum legal size.

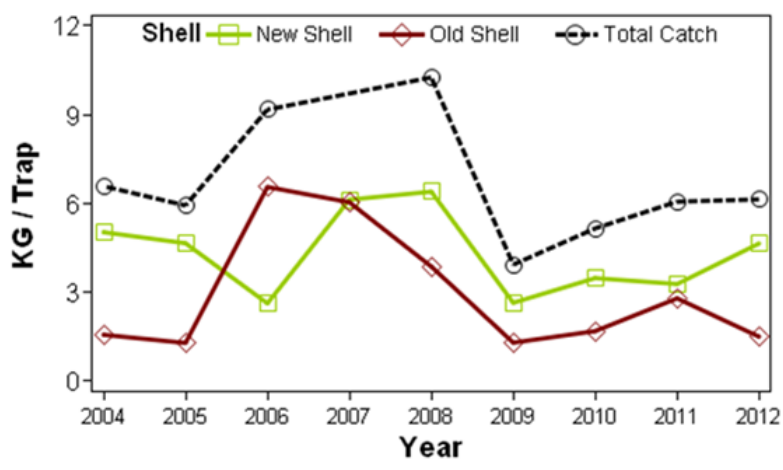


Figure 117: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 3D.

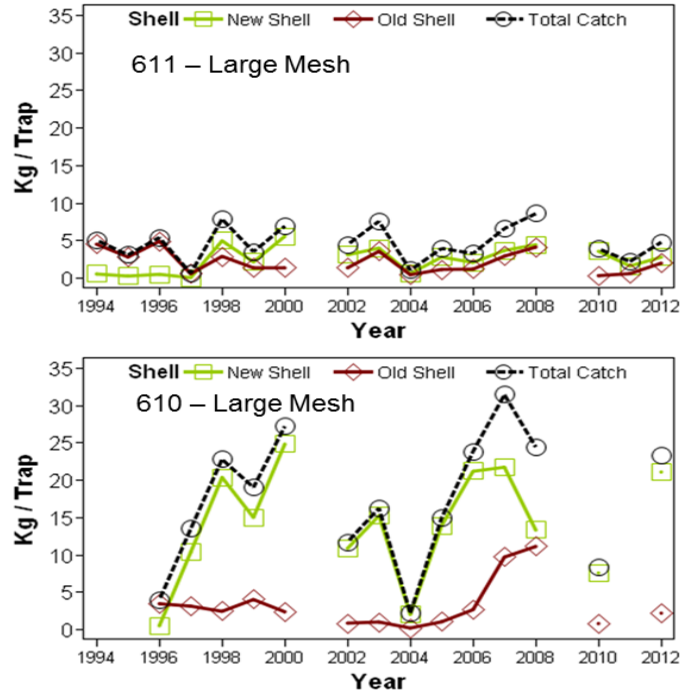


Figure 118: Trends in CPUE by shell condition for legal-sized crabs from strata occupied in the DFO trap survey in Notre Dame Bay. No surveys conducted in 2001 or 2009.

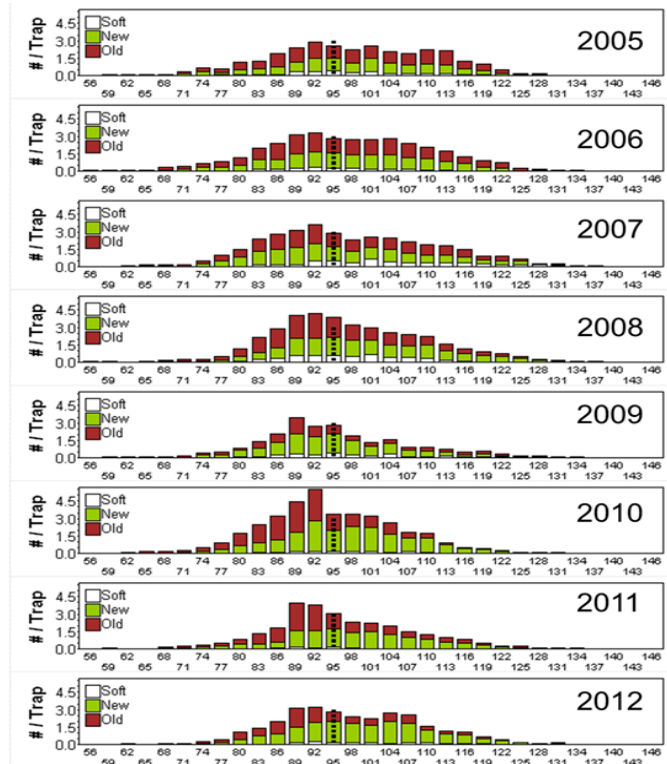


Figure 119: Trends in male carapace width distributions from core stations in CMA 3D from the CPS survey. The vertical dashed line indicates the minimum legal size.

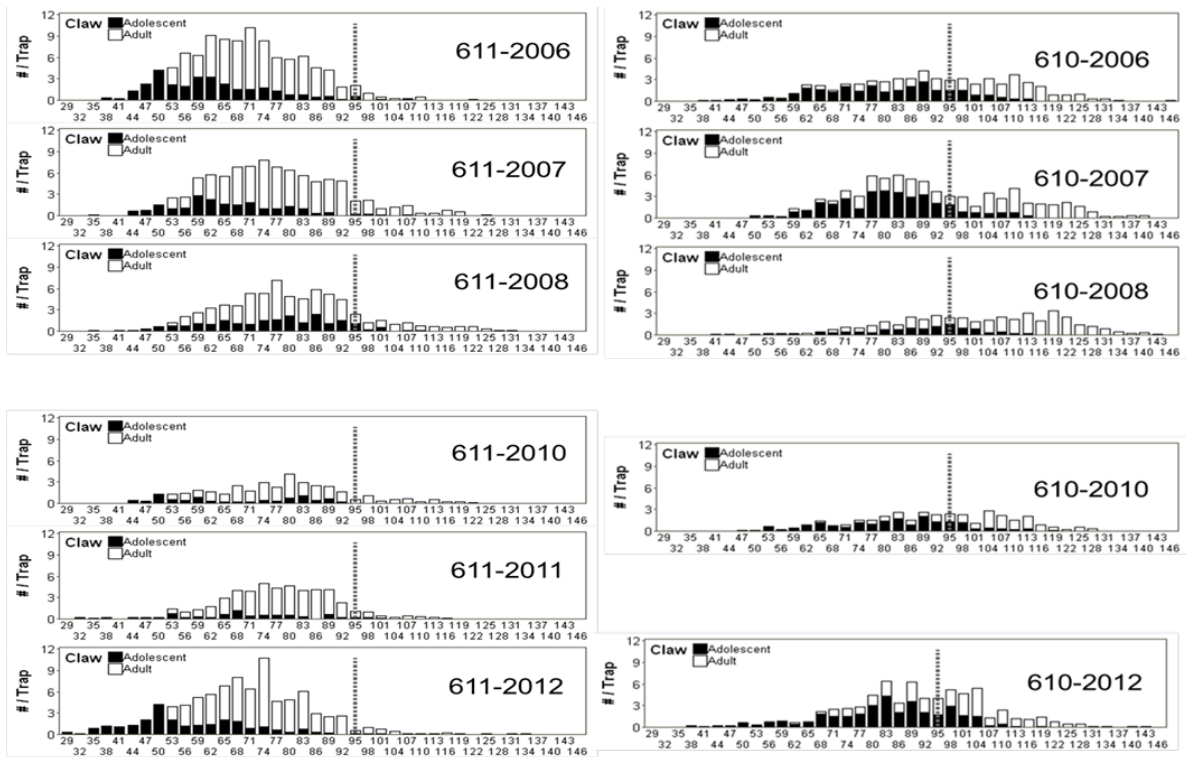


Figure 120: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in DFO trap survey in Notre Dame Bay. The vertical dashed line indicates the minimum legal size.

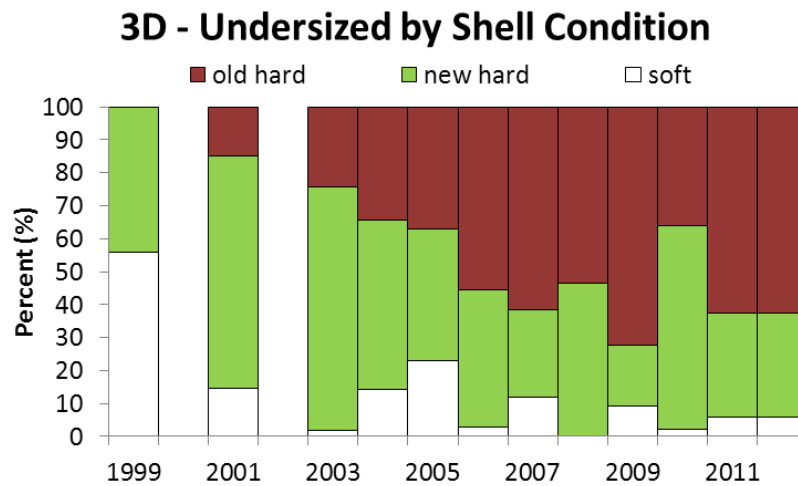


Figure 121: Trends in shell condition of 76-94mm CW crabs from CMA 3D observer sampling.

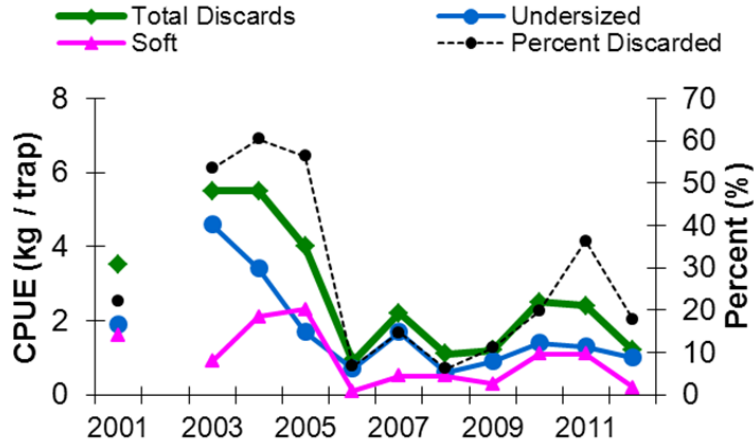


Figure 122: Trends in CMA 3D observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

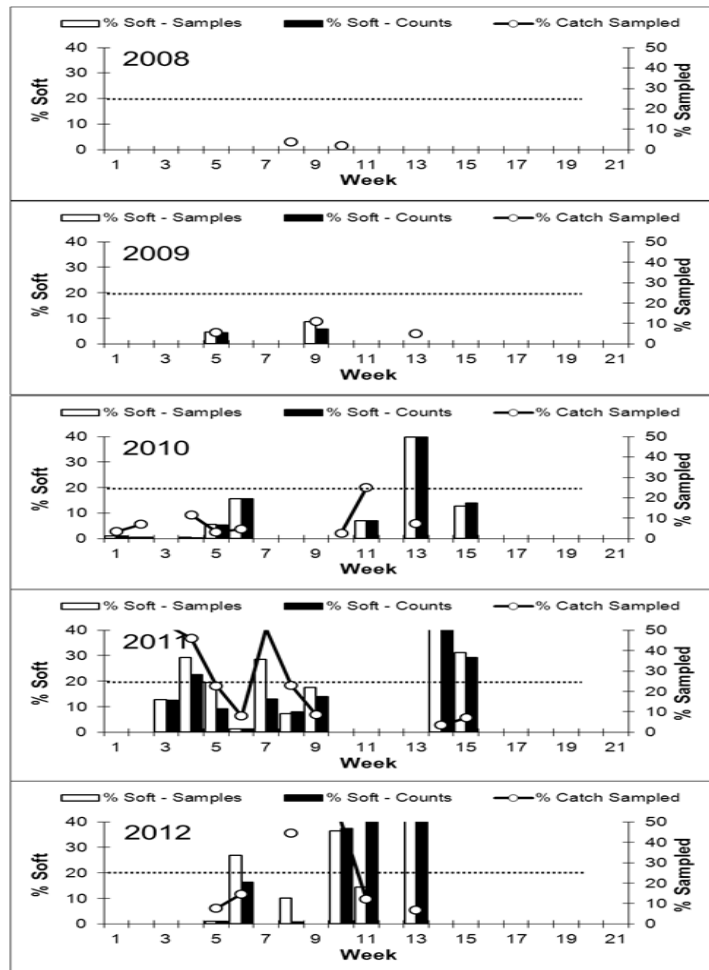


Figure 123: Trends in weekly percentages of soft-shell crab in CMA 3D from at-sea sampling by observers.

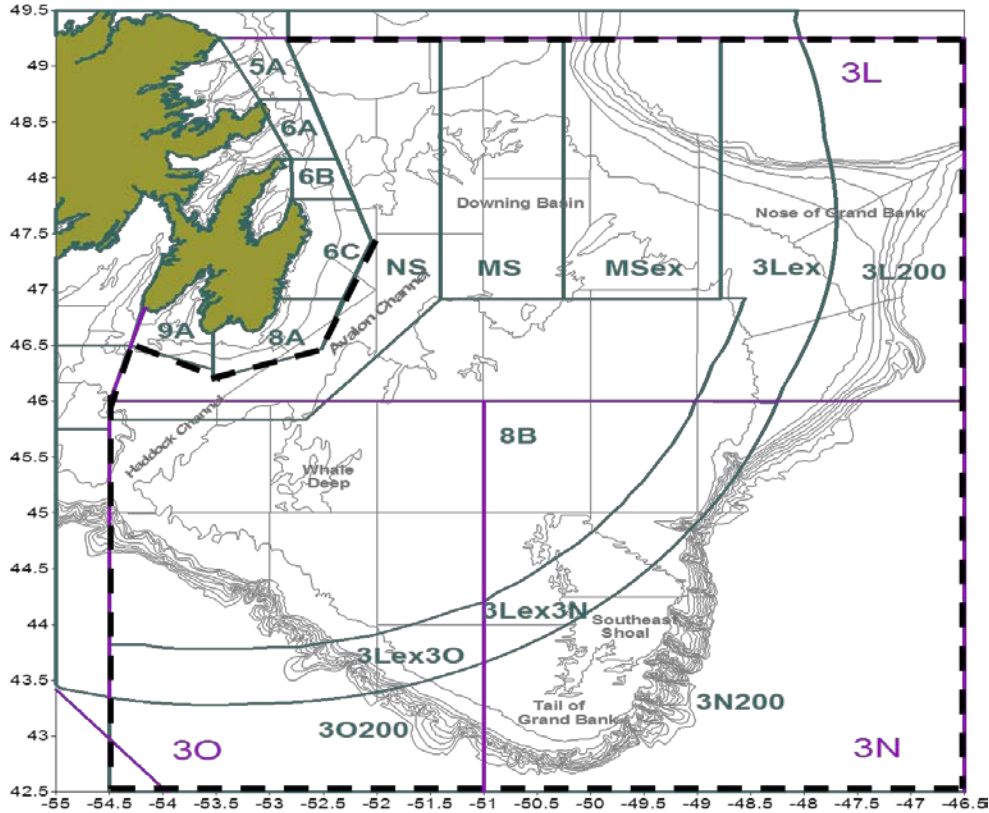


Figure 124: Map of Division 3LNO showing crab management areas and important bathymetric features. Dashed perimeter indicates offshore areas.

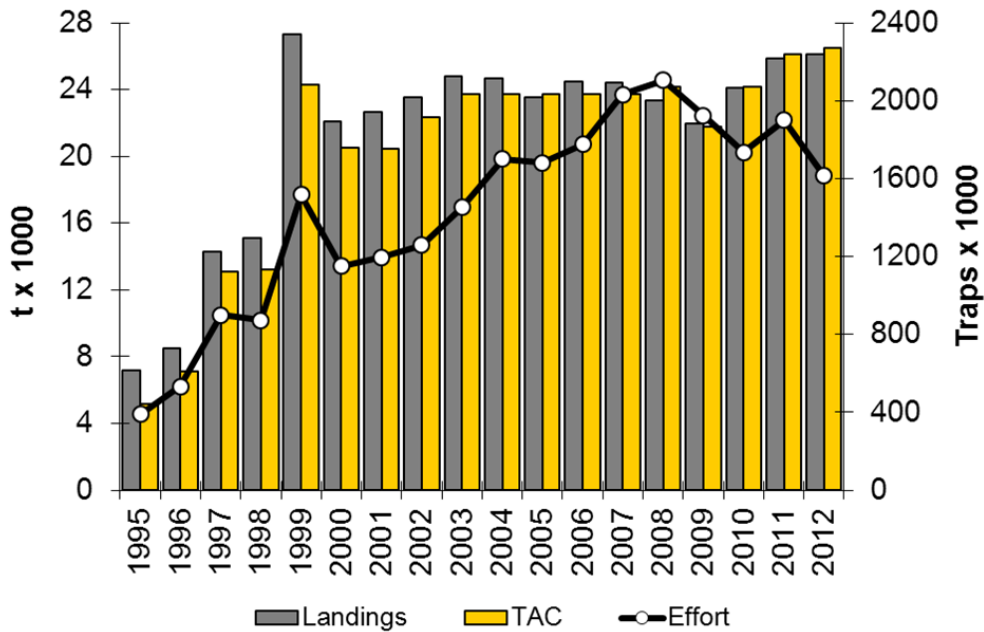


Figure 125: Trends in Div. 3LNO offshore landings, TAC, and fishing effort.

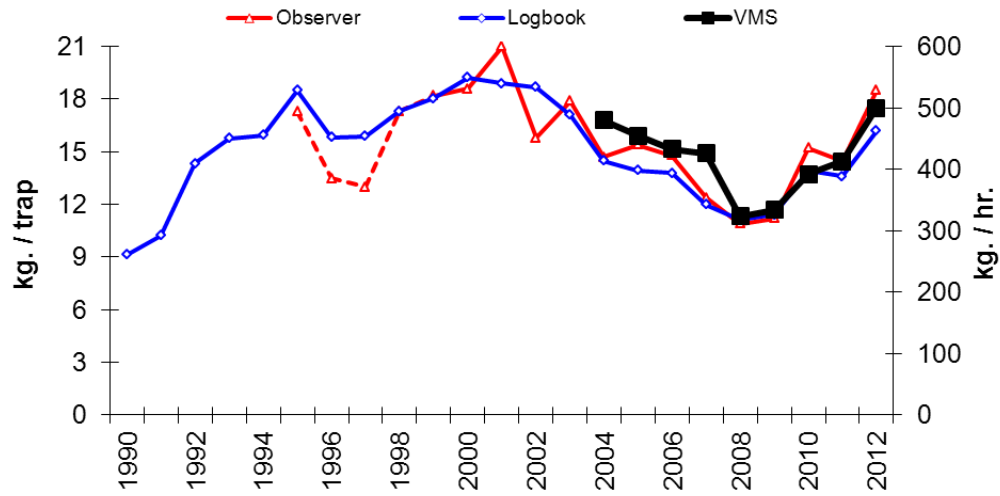


Figure 126: Trends in commercial logbook-based, observer-based, and VMS-based CPUE in the Div. 3LNO offshore fishery.

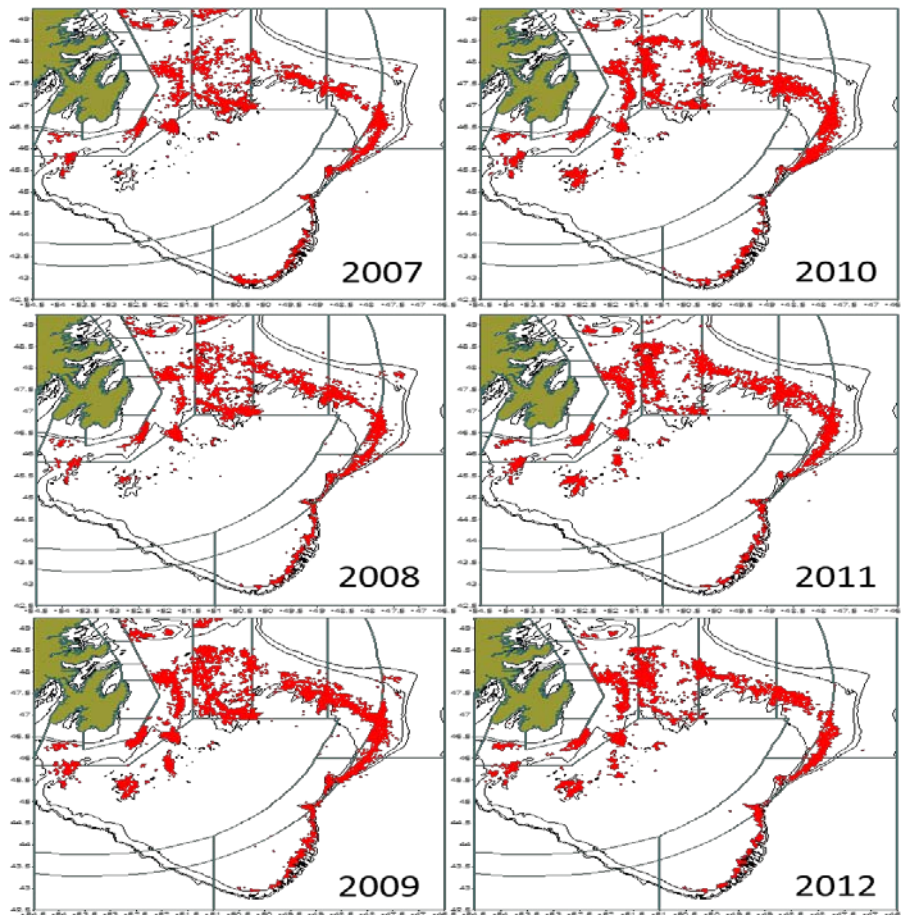


Figure 127: Spatial distribution of Div. 3LNO offshore fishing effort by year.

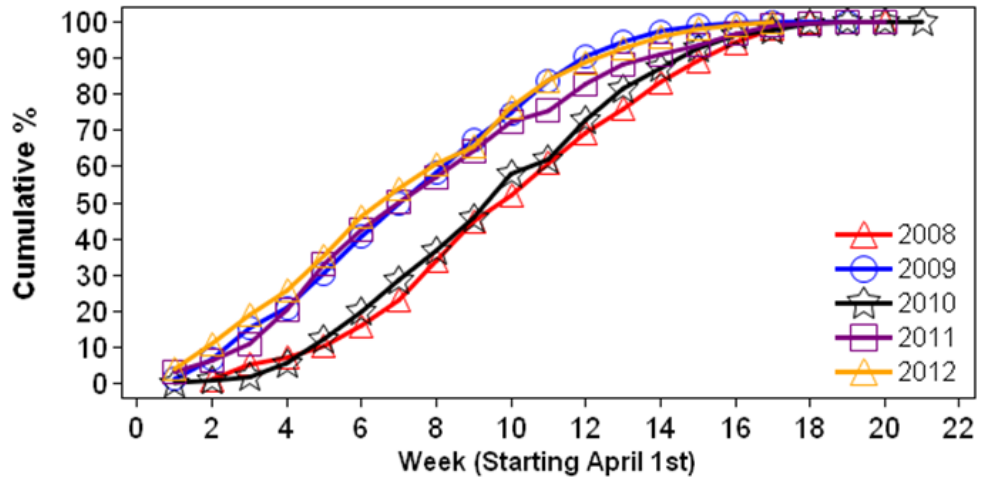


Figure 128: Seasonal trends in fishing effort for Div. 3LNO offshore.

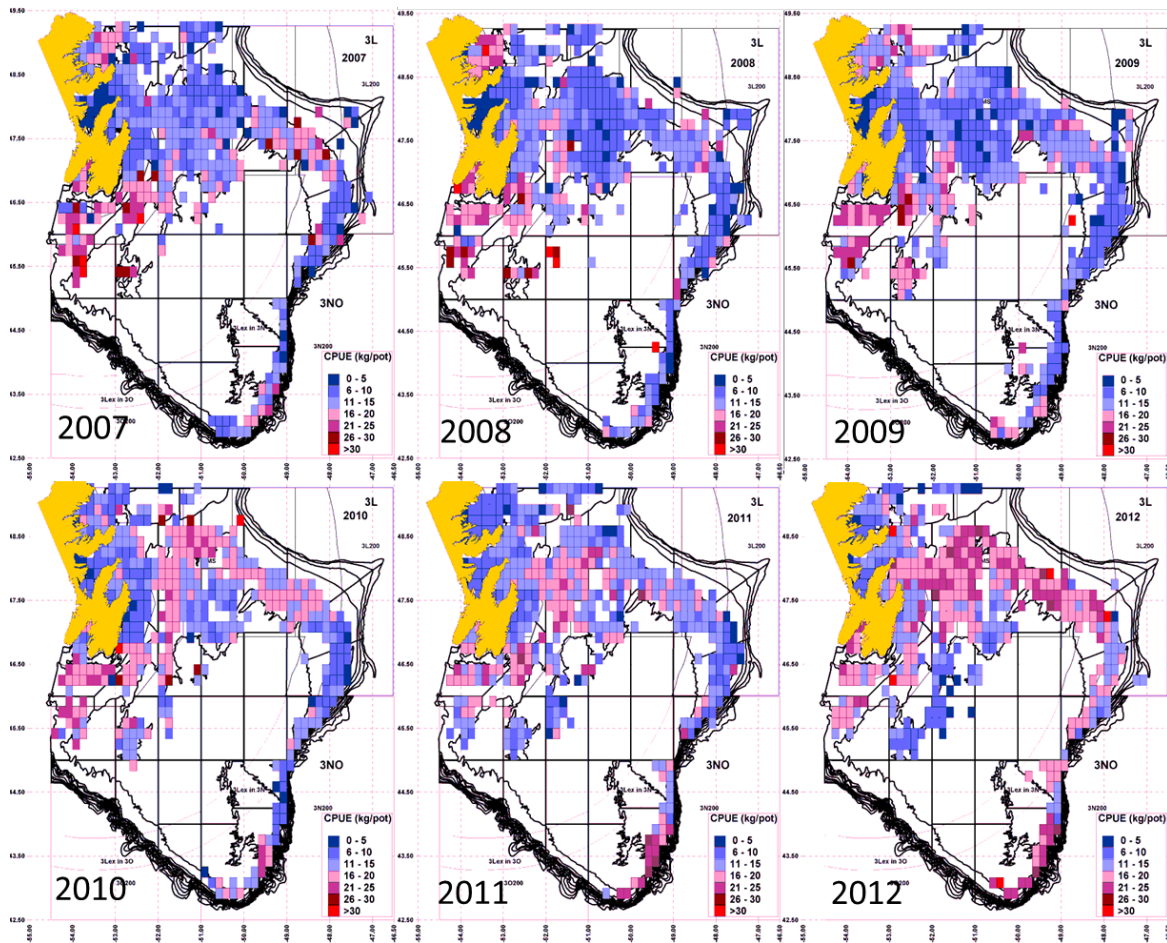


Figure 129: Spatial distribution of Div. 3LNO logbook CPUE by year.

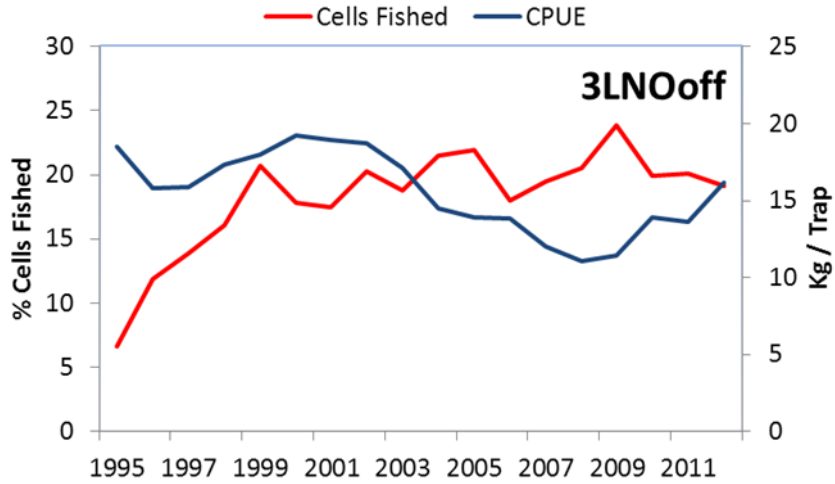


Figure 130: Trends in Div. 3LNO offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

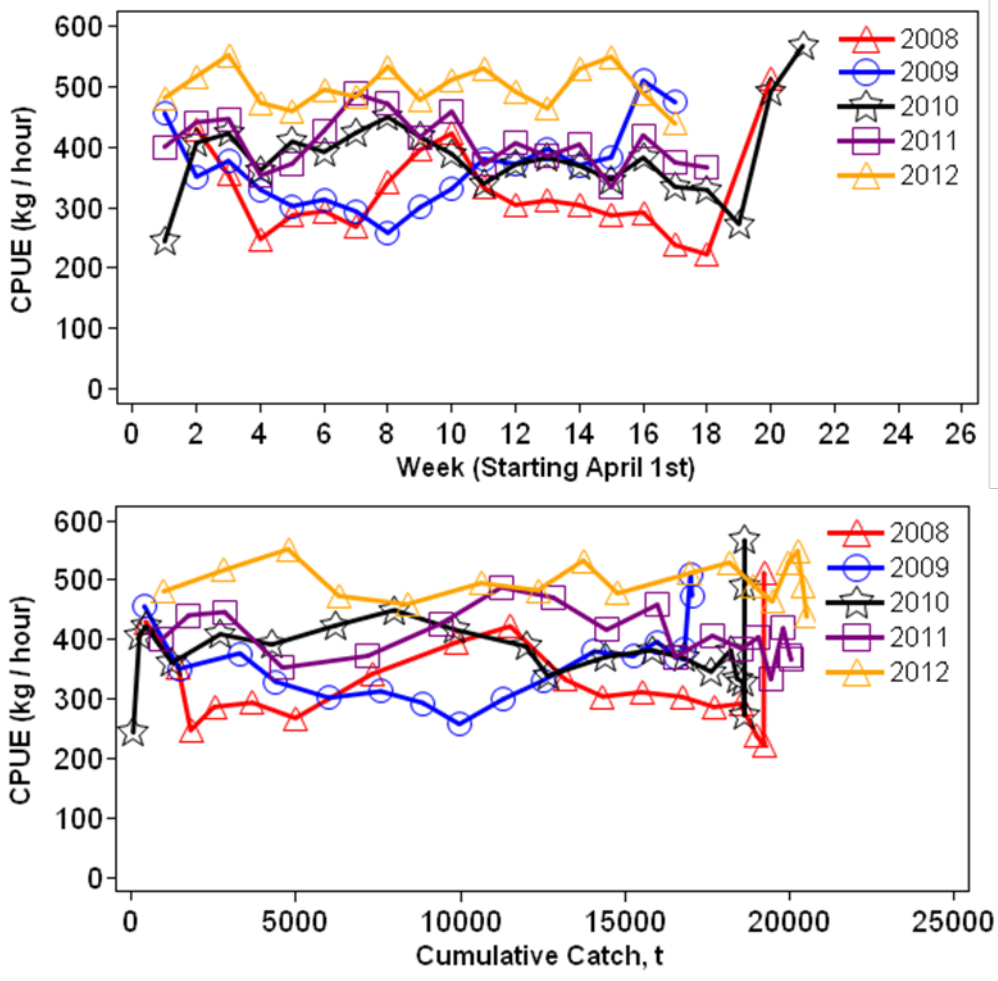


Figure 131: Seasonal trends in VMS-based CPUE for Div. 3LNO offshore; by week (above), and in relation to cumulative catch (below).

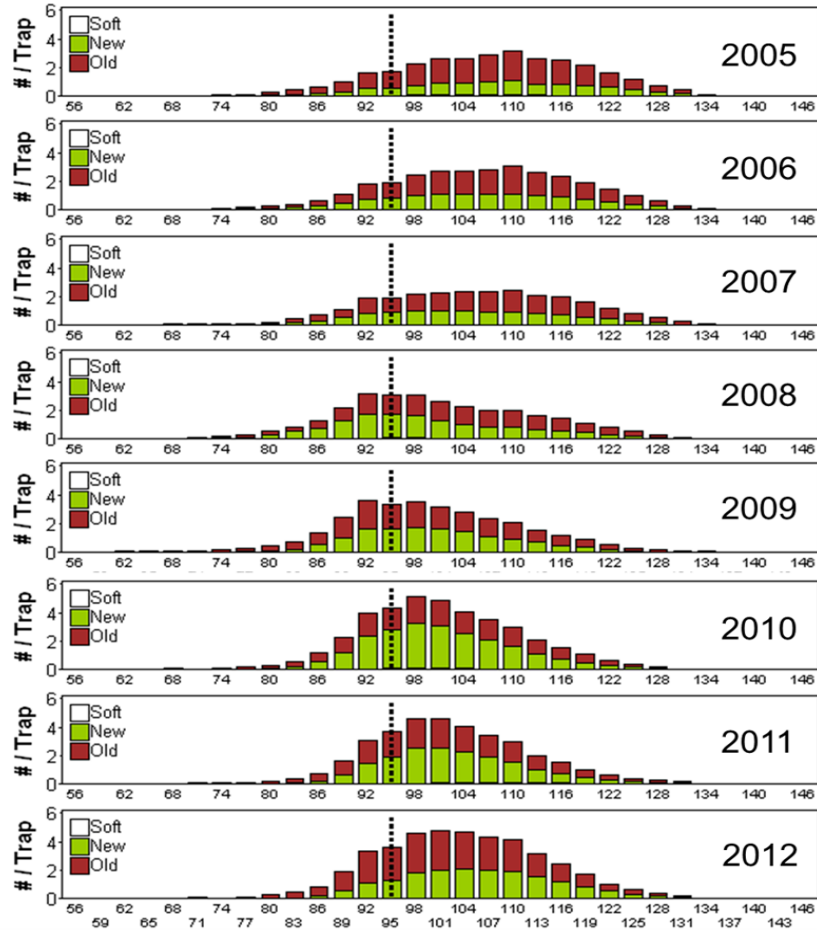


Figure 132: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Div. 3LNO offshore. The vertical dashed line indicates the minimum legal size.

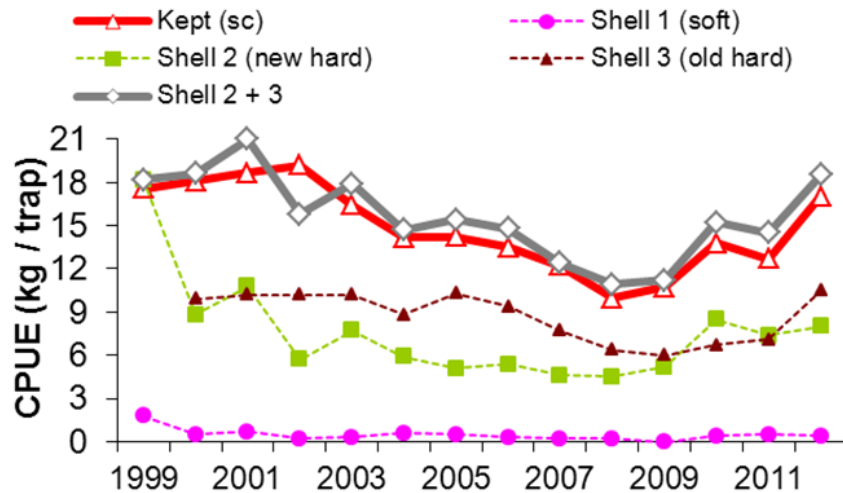


Figure 133: Trends in Division 3LNO offshore observer catch rates of exploitable crabs by shell condition category from at-sea sampling.

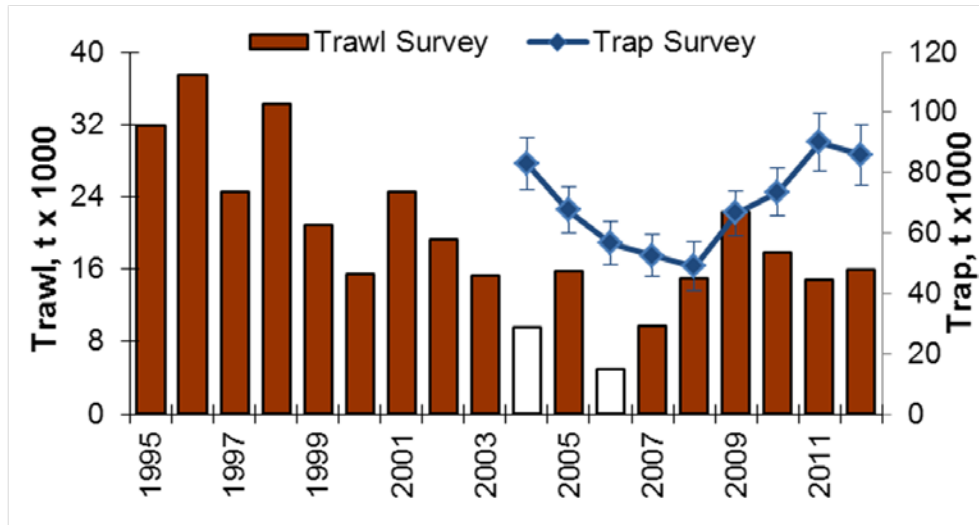


Figure 134: Trends in the Div. 3LNO offshore fall trawl survey exploitable biomass index and the CPS trap survey biomass index. The trawl survey was incomplete in 2004 and 2006.

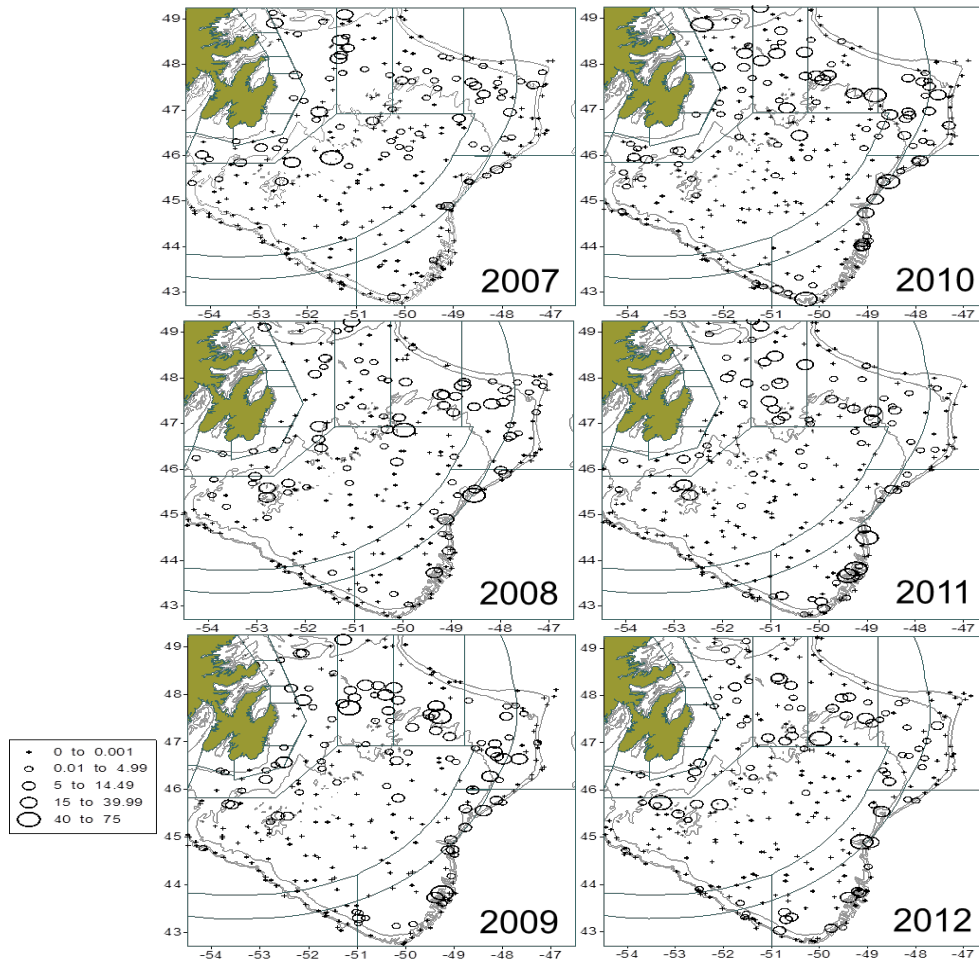


Figure 135. Spatial distribution of catches (number / set) of exploitable snow crab in the Div. 3LNO offshore trawl survey.

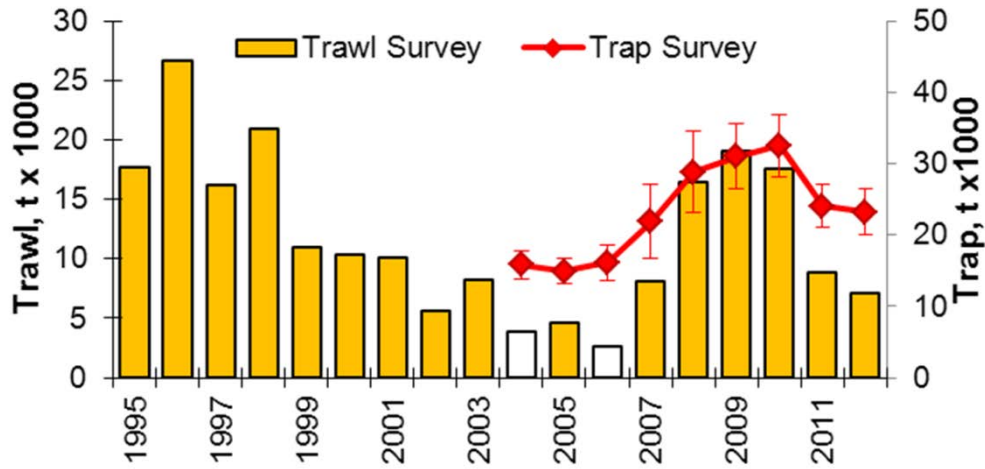


Figure 136: Trends in the Div. 3LNO offshore fall trawl survey pre-recruit biomass index and the CPS trap survey biomass index. The trawl survey was incomplete in 2004 and 2006.

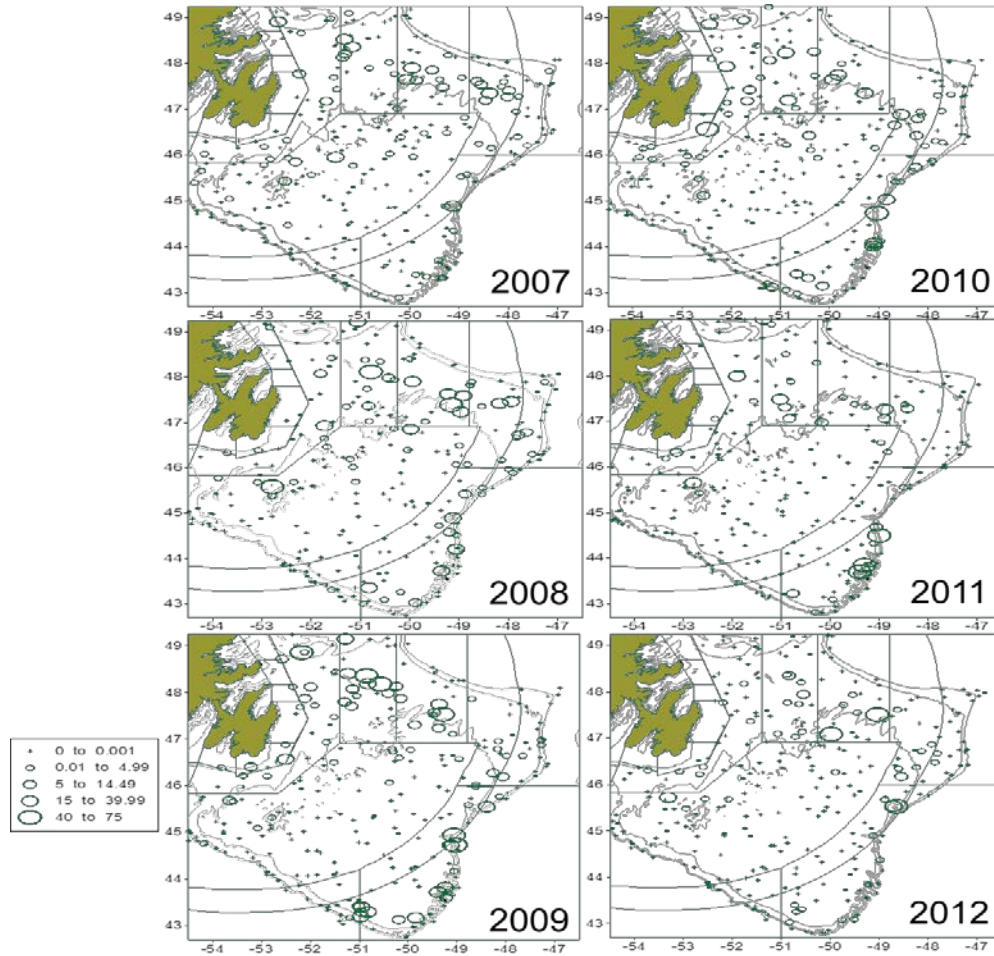


Figure 137. Spatial distribution of catches (number / set) of pre-recruit snow crab in the Div. 3LNO offshore trawl survey.

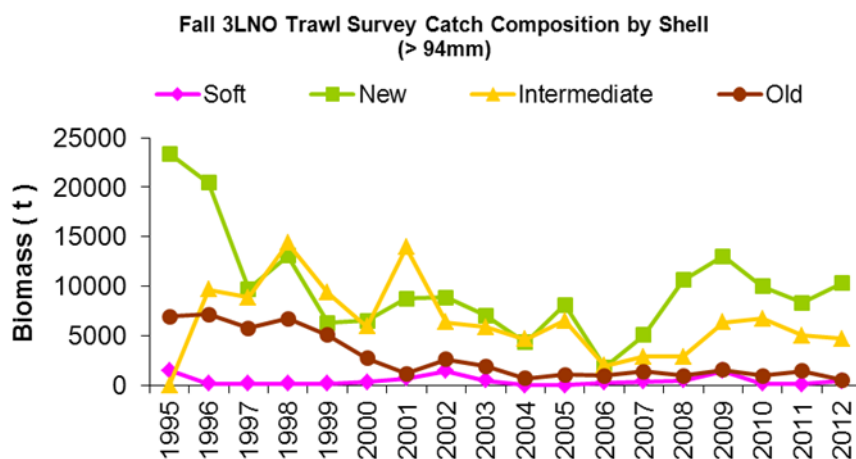


Figure 138: Trends, by shell condition, in biomass of legal-sized males for Div. 3LNO offshore from fall trawl surveys.

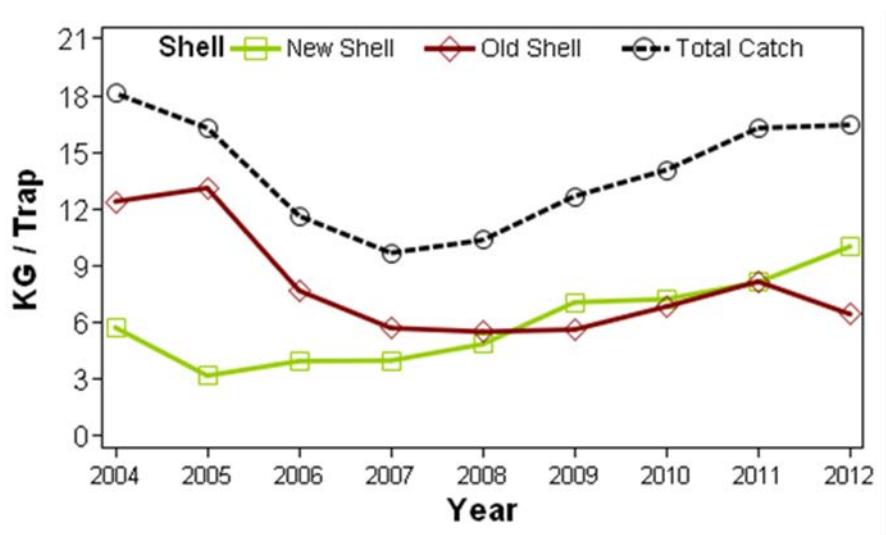


Figure 139: Trends in CPUE by shell condition for legal-sized crabs from core stations in the Div. 3LNO offshore CPS trap survey.

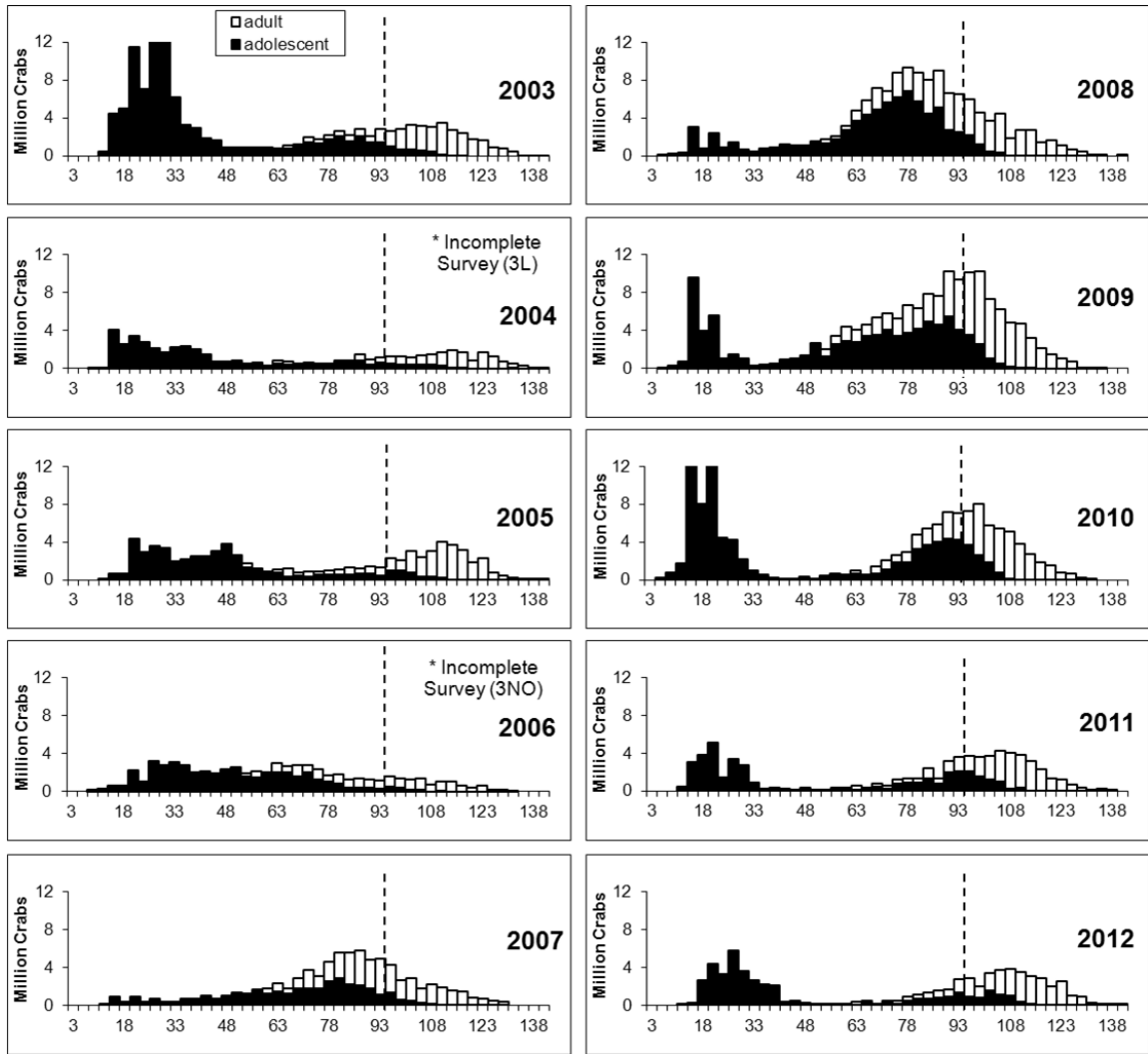


Figure 140: Abundance indices by carapace width for Div. 3LNO juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys.

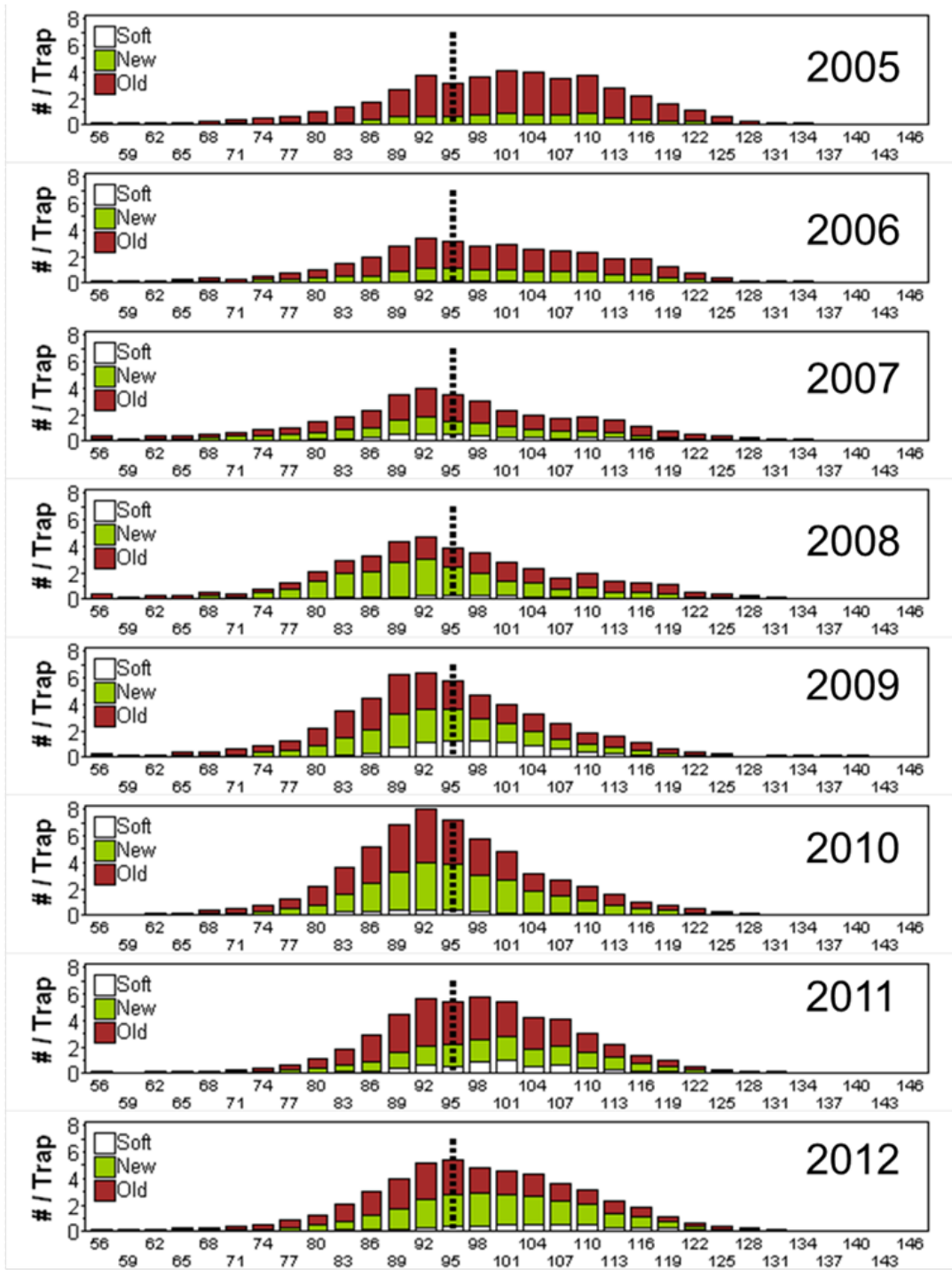


Figure 141: Trends in male carapace width distributions from core stations in the Div. 3LNO offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

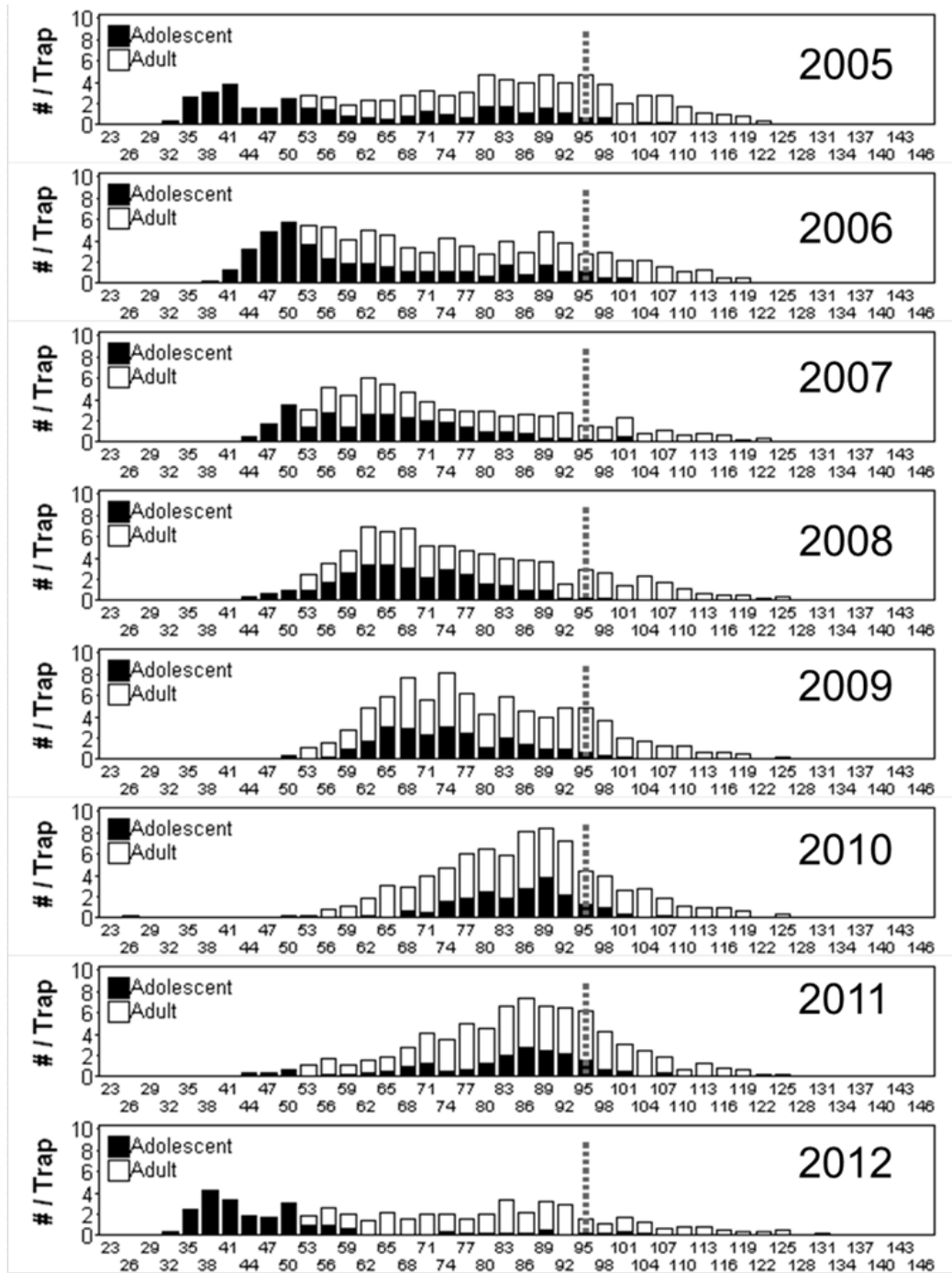


Figure 142: Trends in male carapace width distributions from small-mesh traps in the Div. 3LNO offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

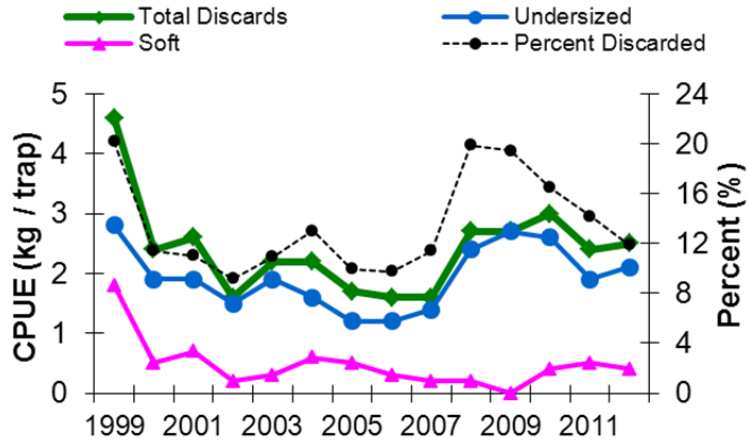


Figure 143: Trends in Division 3LNO offshore observer catch rates of total discards, under-sized discards, and legal-sized discards, as well as the percentage of the catch discarded.

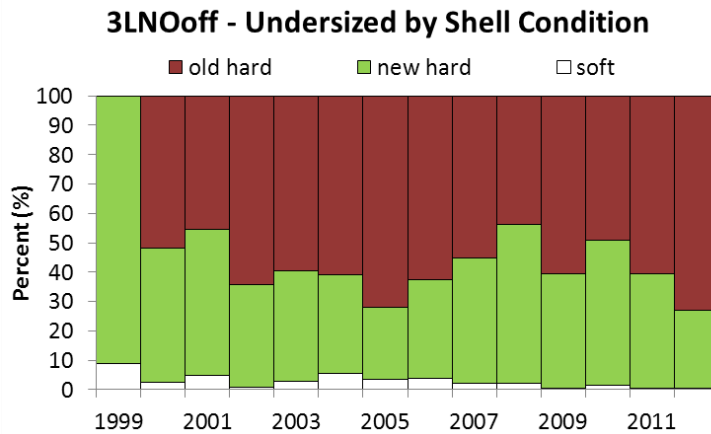


Figure 144: Trends in shell condition of 76-94mm CW crabs from Division 3LNO offshore observer sampling.

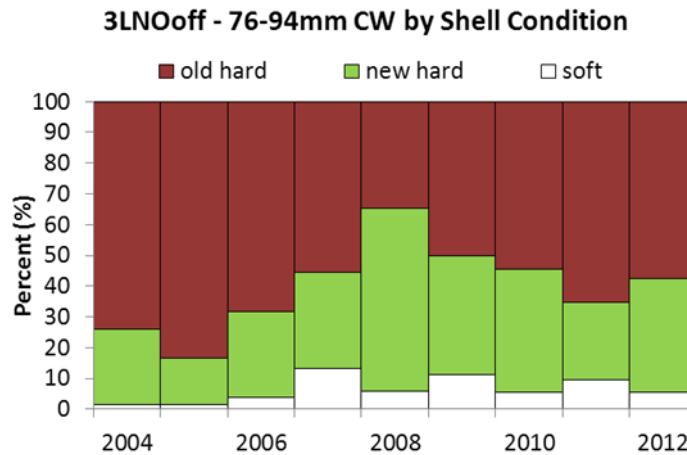


Figure 145: Trends in shell condition of 76-94mm CW crabs from Division 3LNO offshore CPS trap survey.

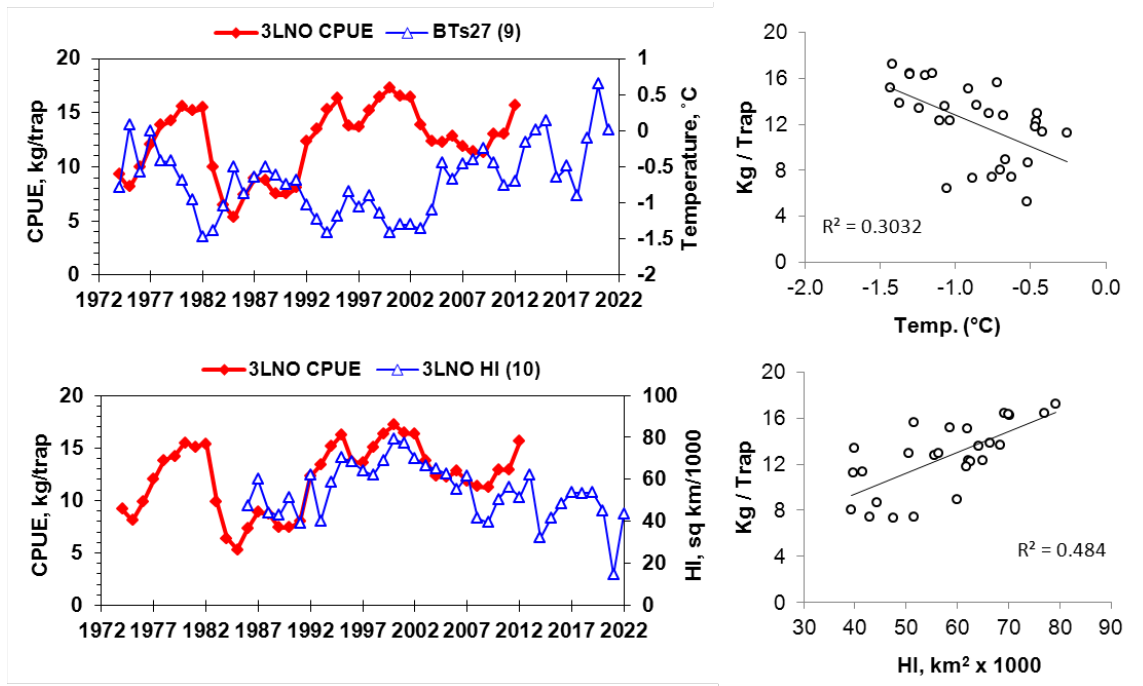


Figure 146: Trends in the Div. 3LNO offshore CPUE vs. bottom temperature at a nine year lag (above) and vs. the spatial extent of <1 degree water at a ten year lag (below), with corresponding scatter plots (right)

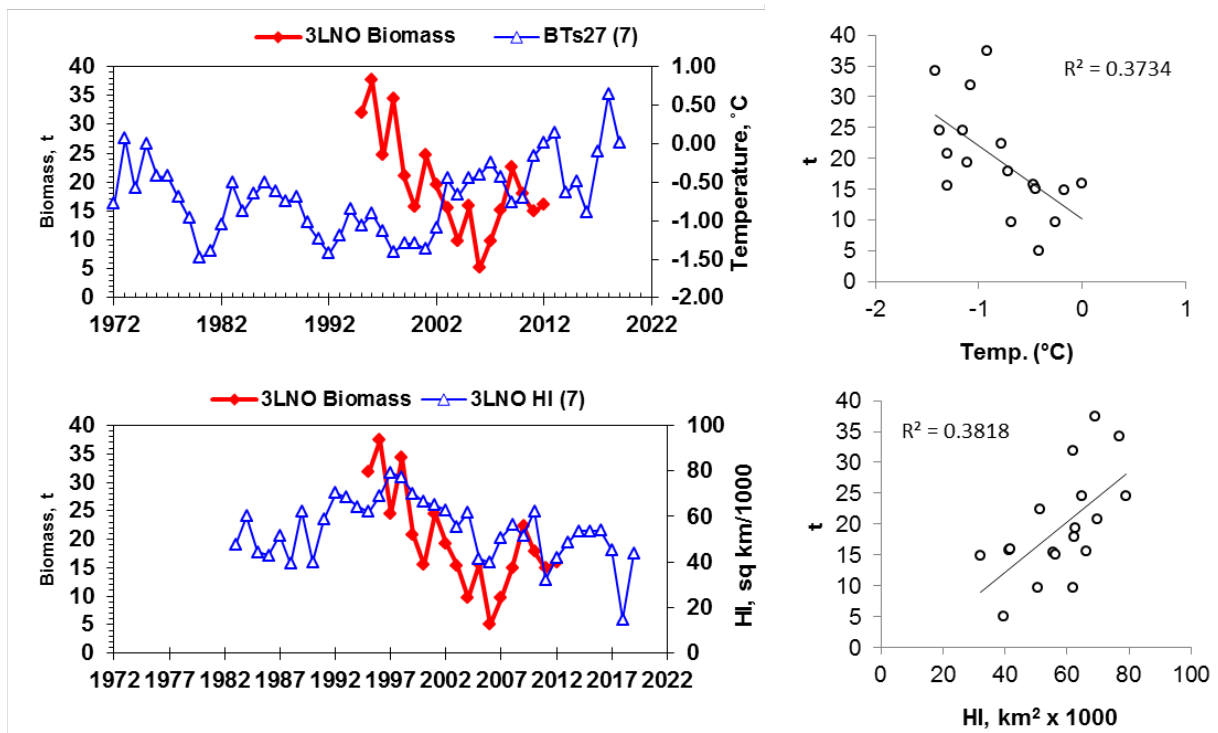


Figure 147: Trends in the Div. 3LNO exploitable biomass index vs. bottom temperature (above) and spatial extent of <1 degree water (below) at a seven year lag (left) with corresponding scatter plots (right).

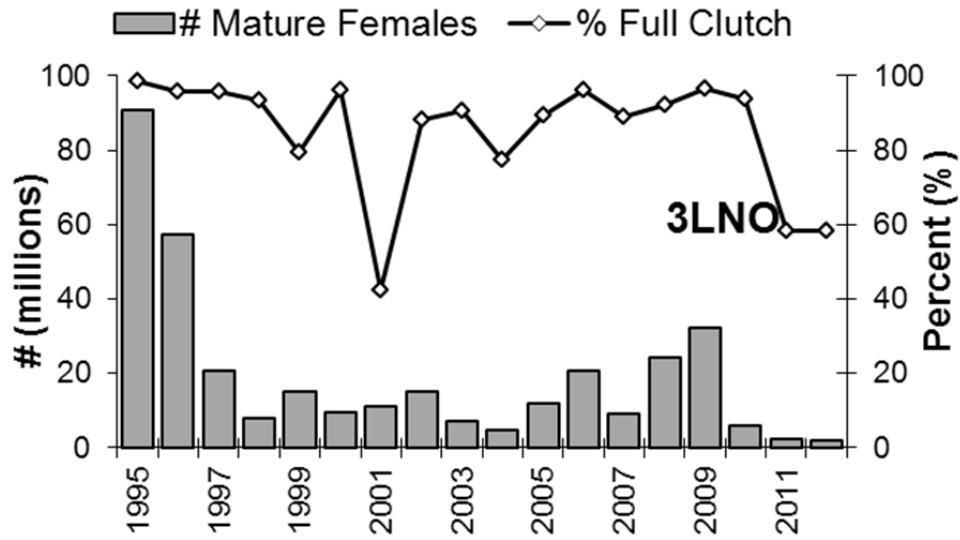


Figure 148: Trends in percent of mature females as well as the percentage of mature females bearing full clutches of viable eggs in Div. 3LNO from fall multi-species surveys.

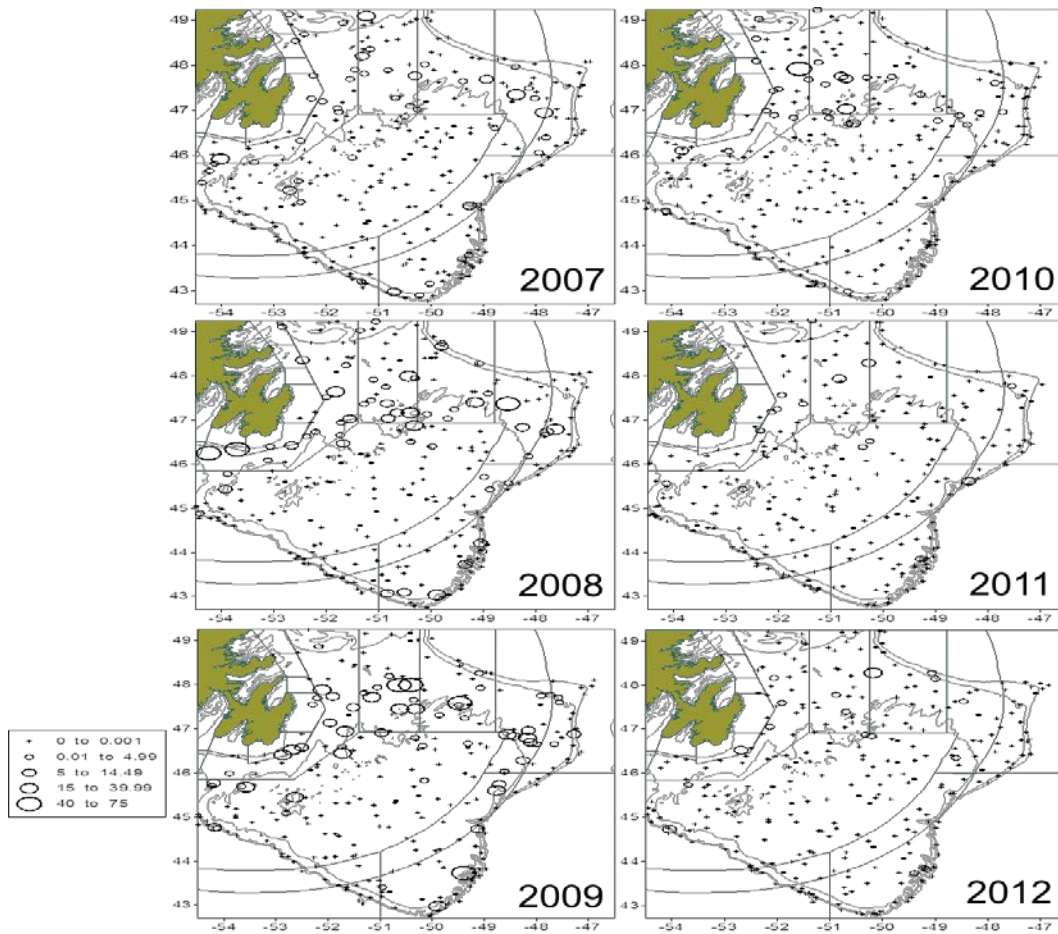


Figure 149: Spatial distribution of catches (number/set) of mature females in the Div. 3LNO fall trawl survey from 2007-2012.

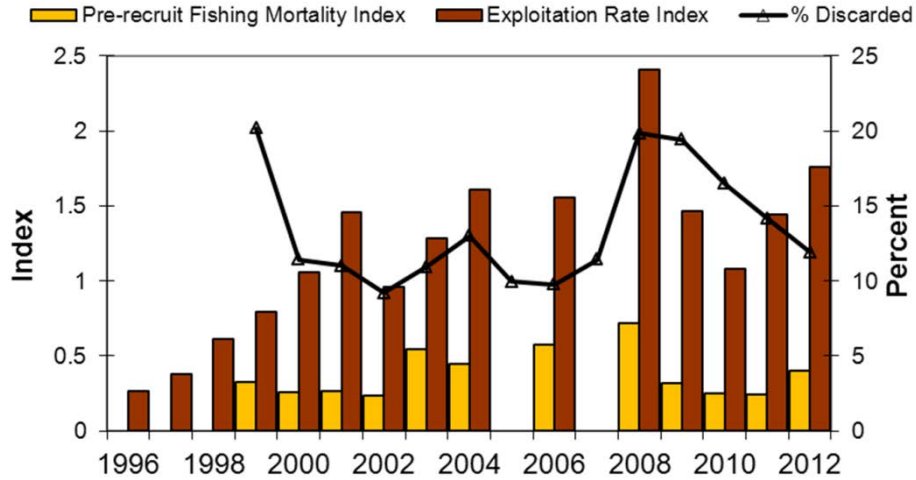


Figure 150: Trends in Div. 3LNO offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality rate index) and in the percentage of the catch discarded in the fishery (no 2005 or 2007 exploitation rate or pre-recruit fishing mortality indices because of incomplete 2004 and 2006 surveys).

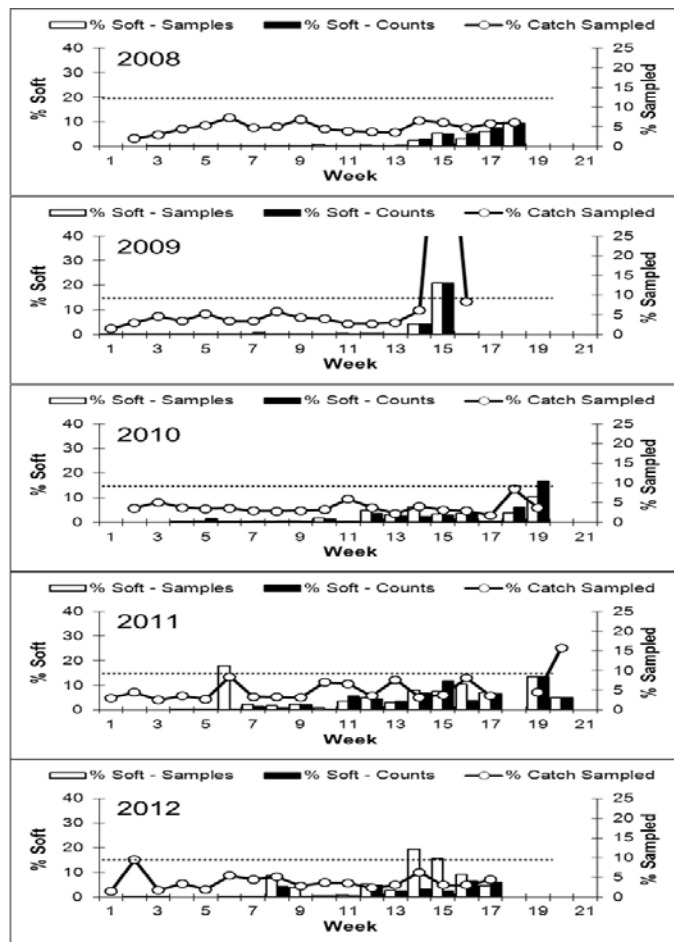


Figure 151: Trends in weekly percentages of soft-shell crab in Div. 3LNO from at-sea sampling by observers.

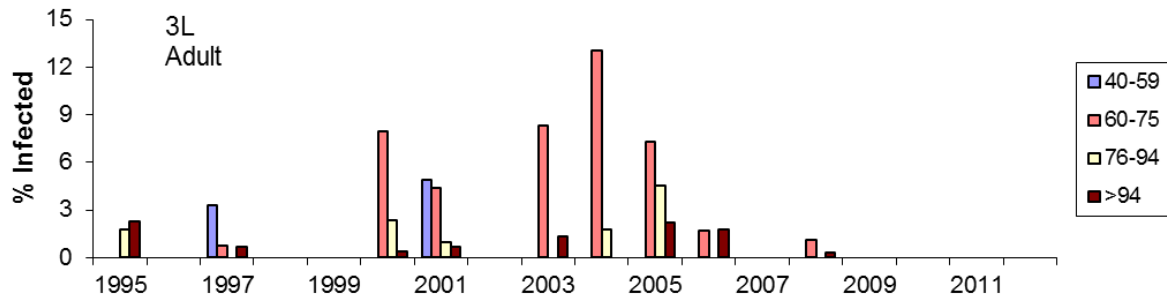
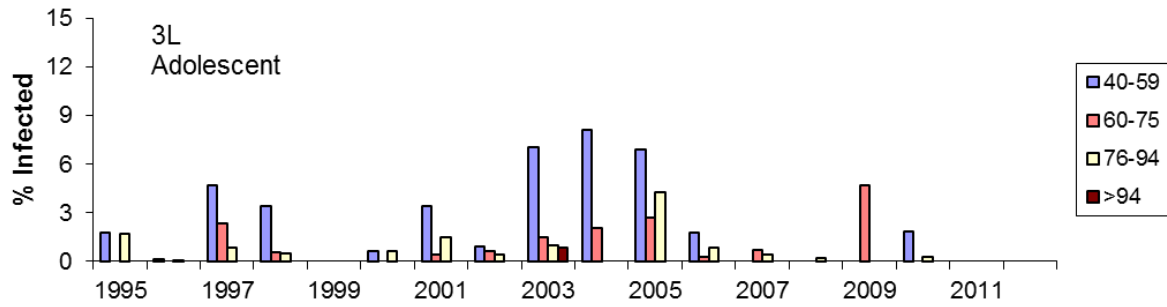


Figure 152: Annual trends in prevalence of BCD in new-shelled adolescent (above) and adult (below) males by size group from Div. 3L fall trawl surveys.

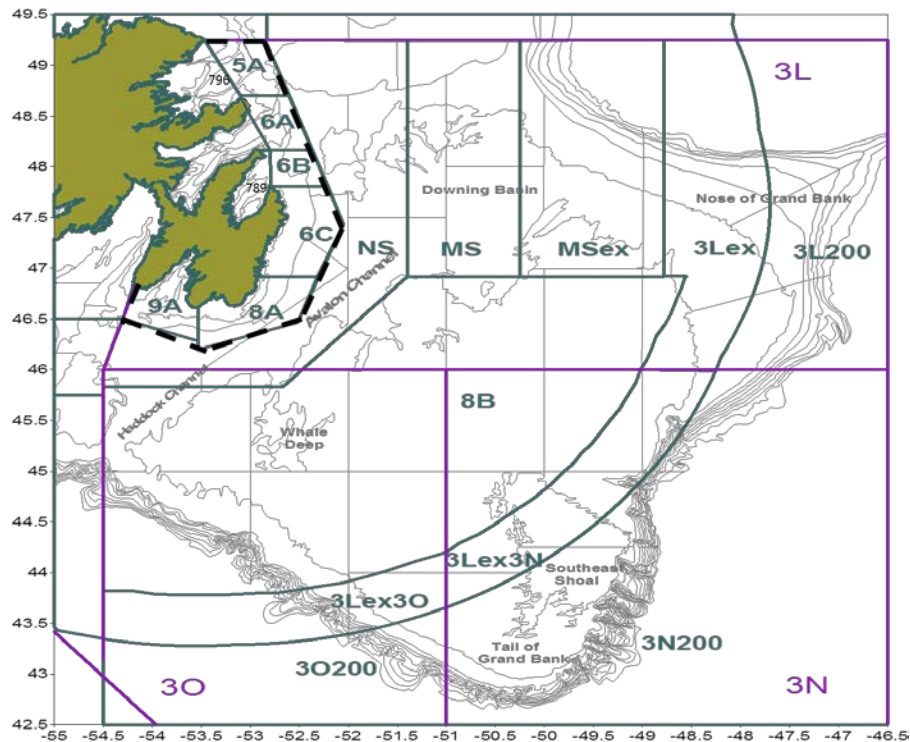


Figure 153: Map of Division 3LNO showing crab management areas and important bathymetric features. Dashed perimeter indicates Div. 3L inshore areas.

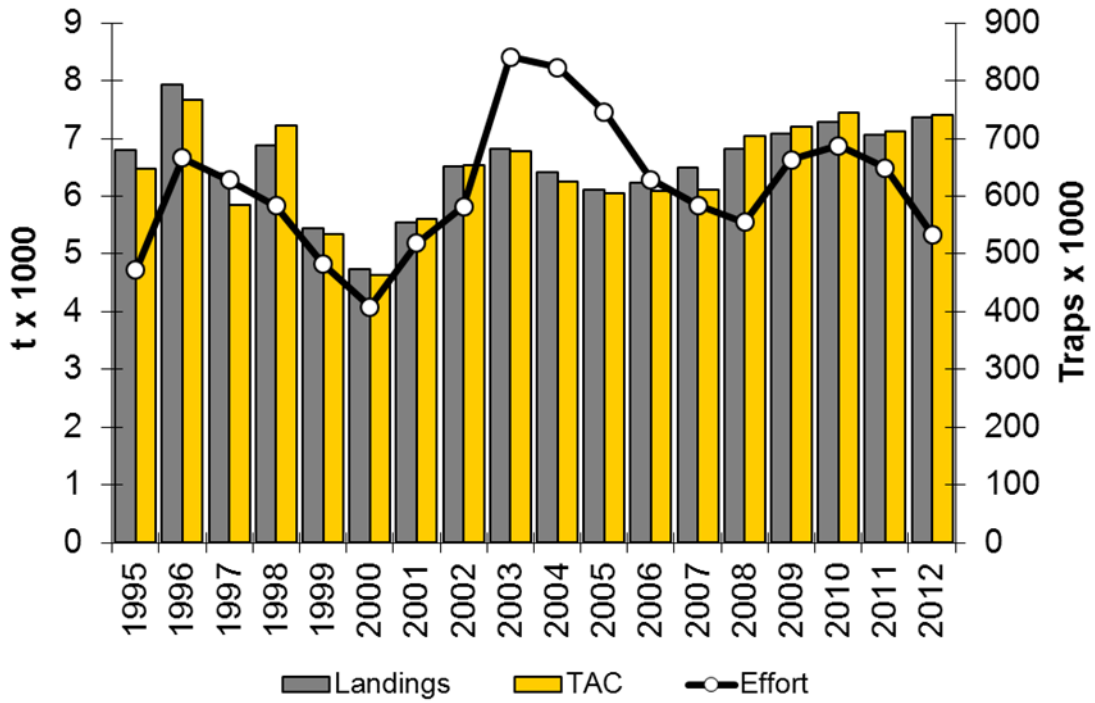


Figure 154: Trends in Div. 3L inshore landings, TAC, and fishing effort.

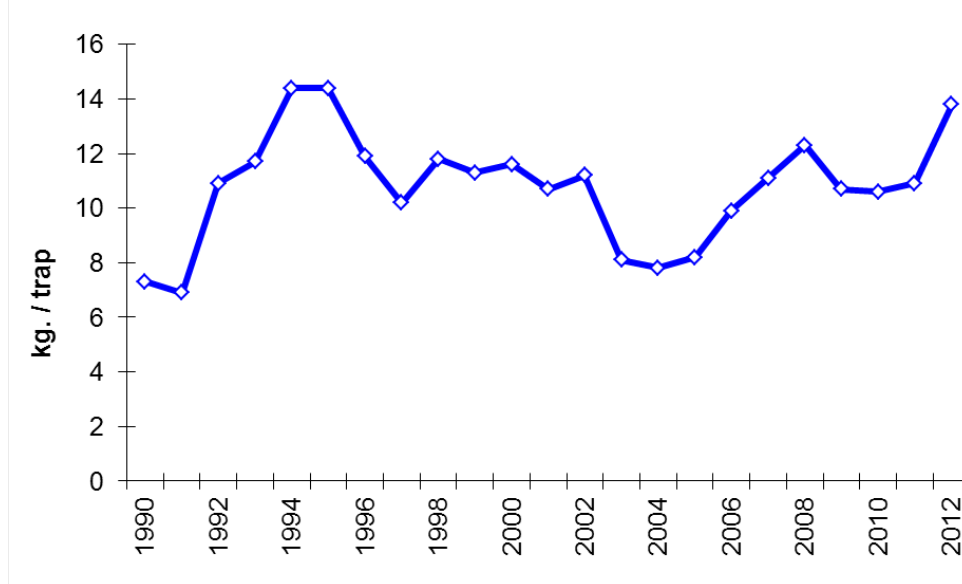


Figure 155: Trends in commercial logbook-based CPUE in the Div. 3L inshore fishery.

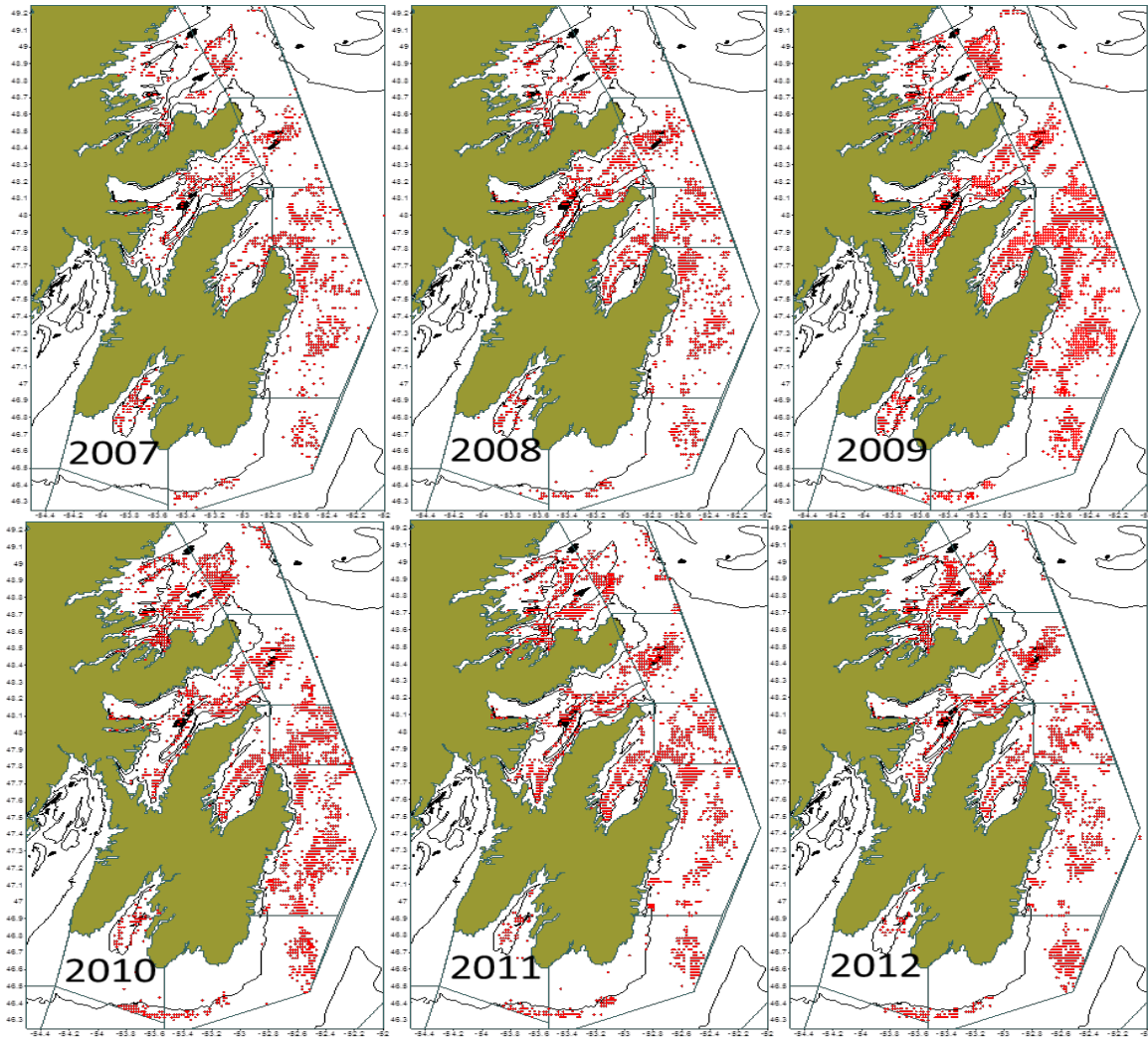


Figure 156: Spatial distribution of Div. 3L inshore fishing effort by year.

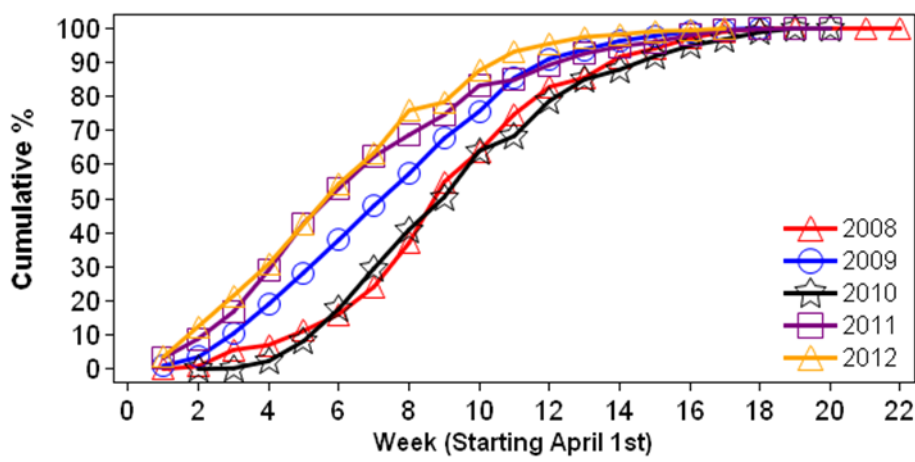


Figure 157: Seasonal trends in weekly fishing effort for Div. 3L inshore.

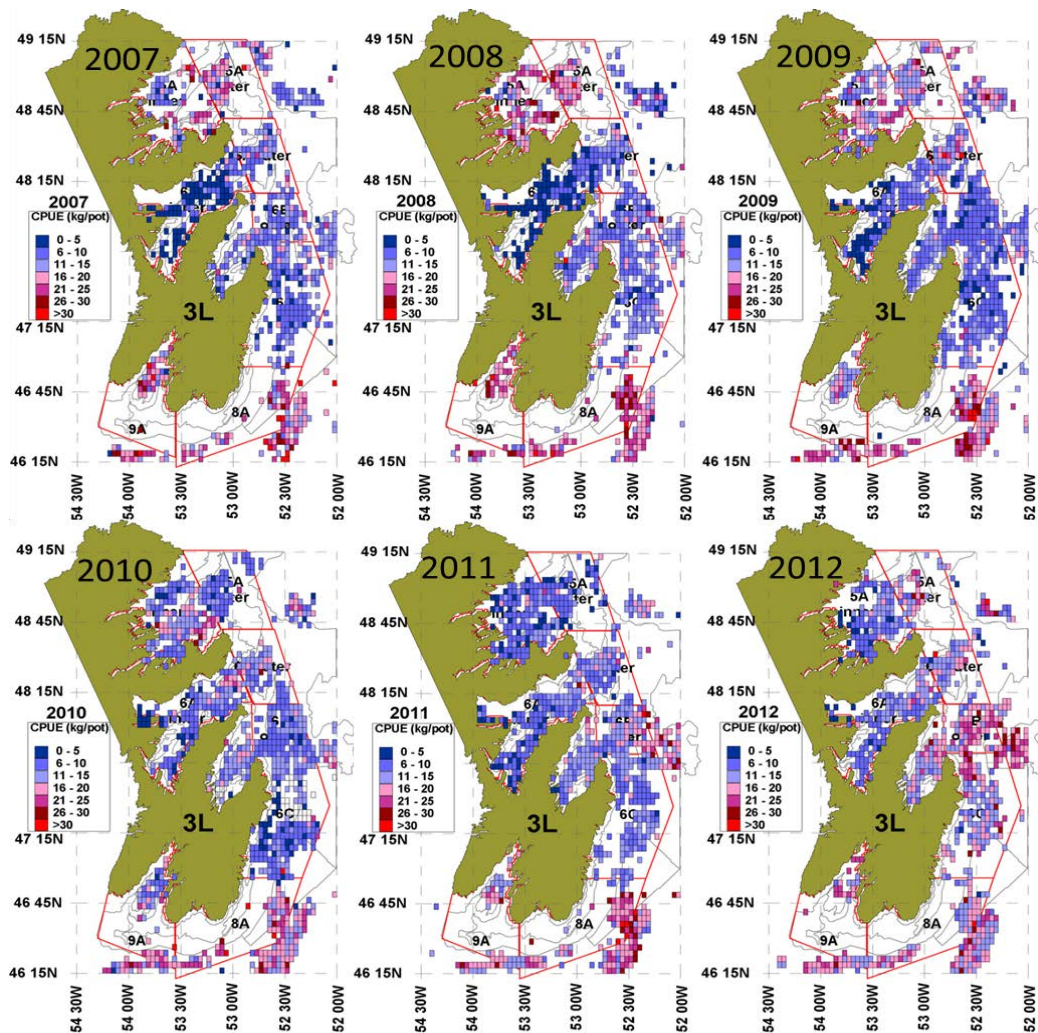


Figure 158: Spatial distribution of Div. 3L inshore logbook CPUE by year.

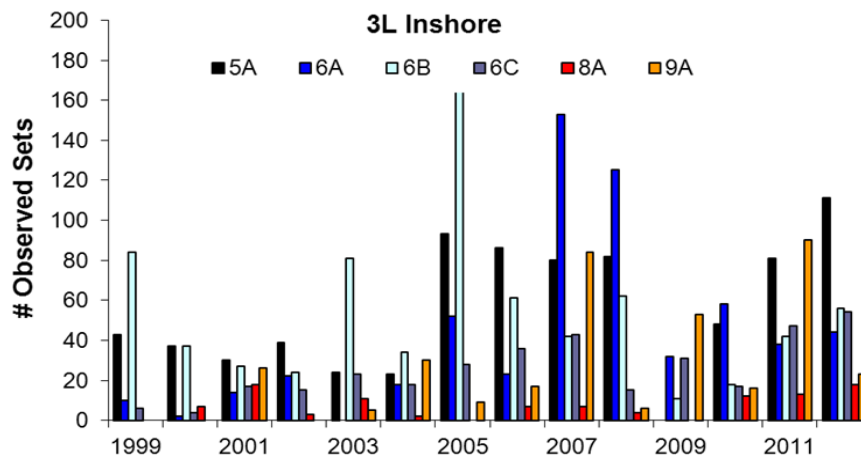


Figure 159: Trends in number of observed sets by Crab Management Areas and year in Division 3L inshore.

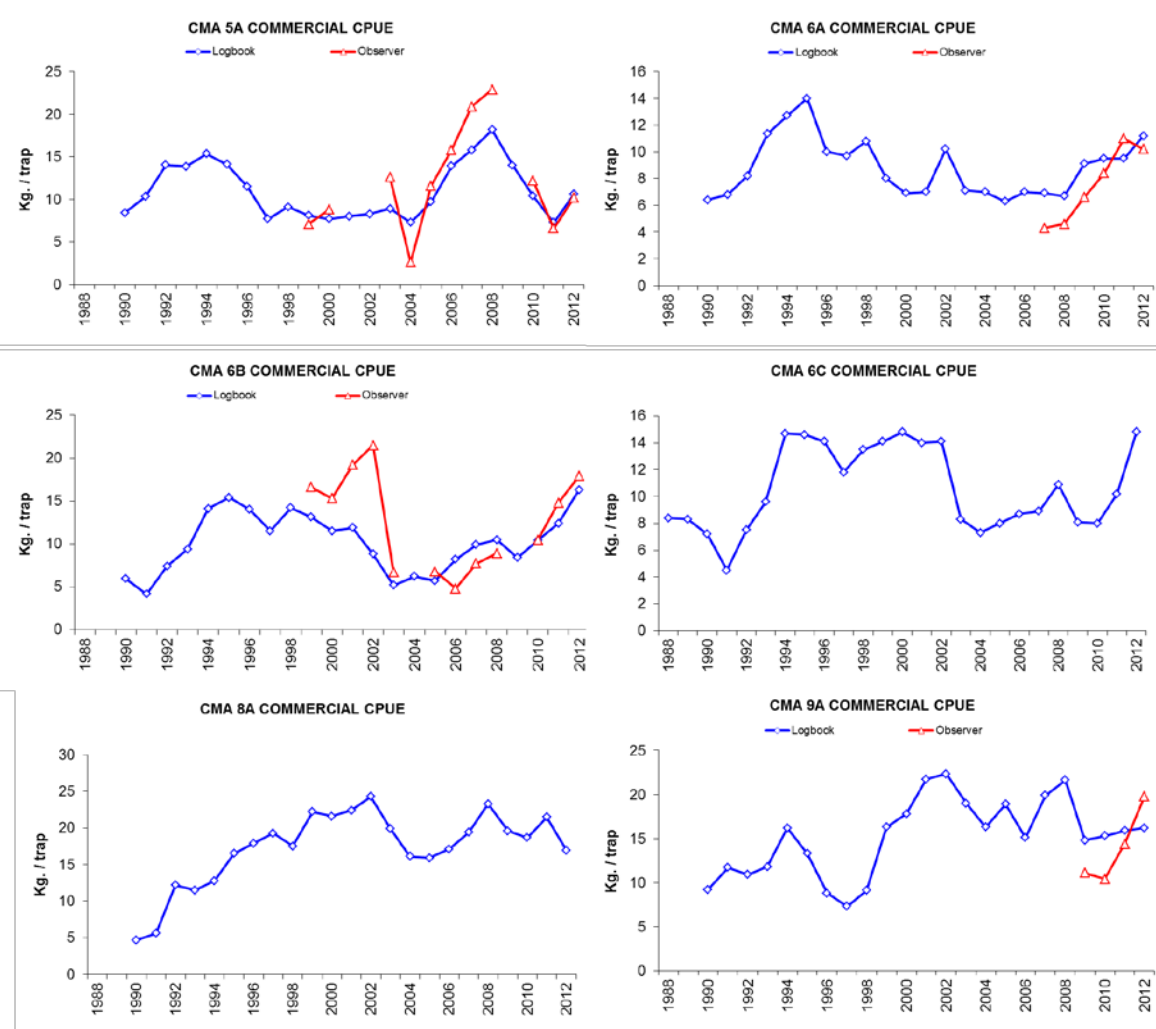


Figure 160: Trends in Division 3L inshore logbook CPUE and observer CPUE by Crab Management Area.

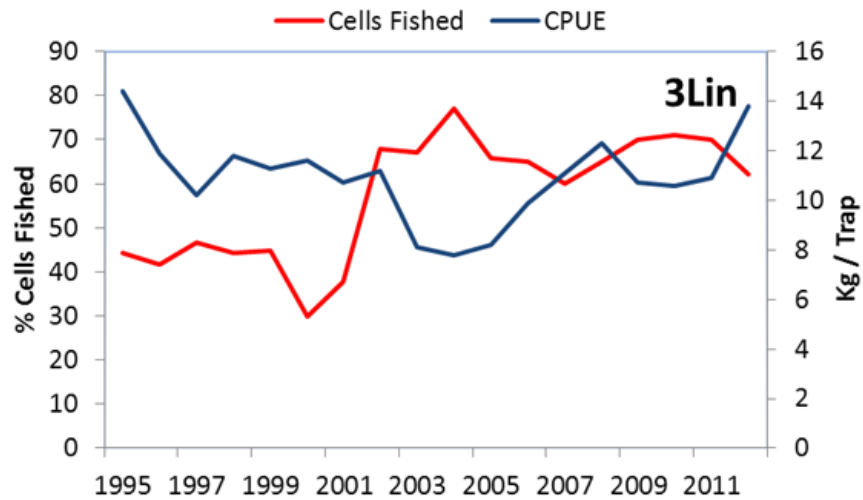


Figure 161: Trends in Div. 3L inshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

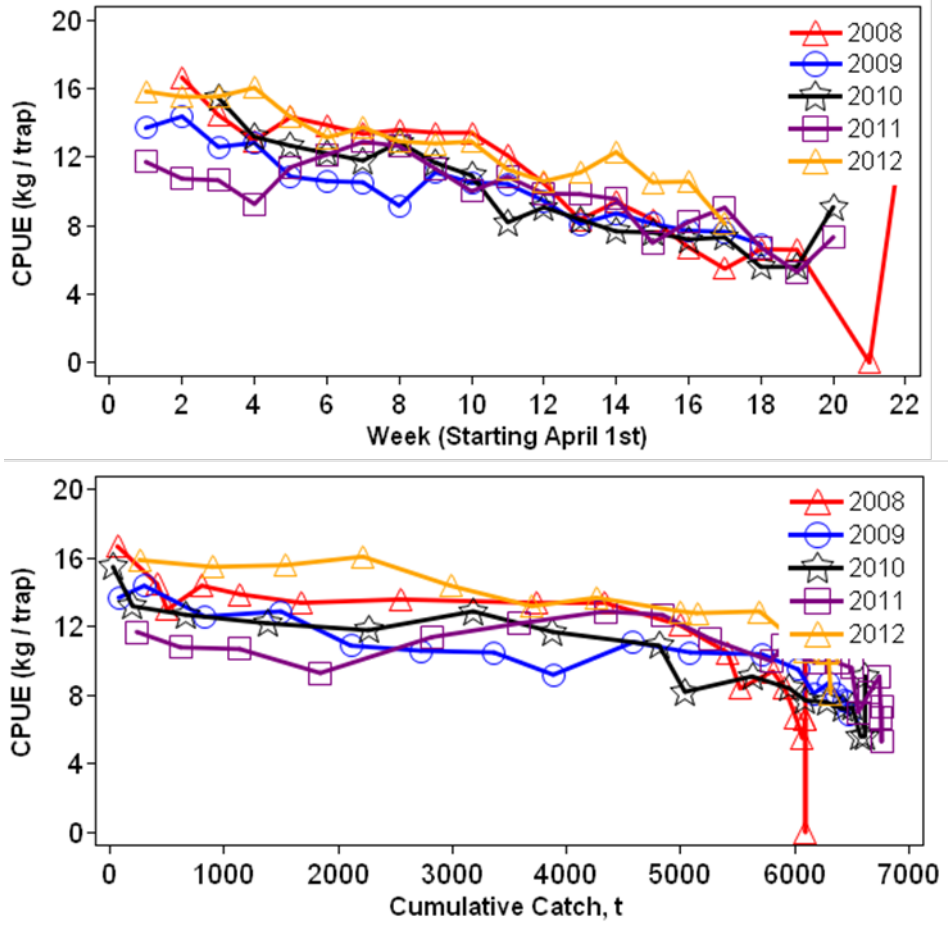


Figure 162: Seasonal trends in logbook-based CPUE for Div. 3L inshore; by week, (above) and in relation to cumulative catch (below).

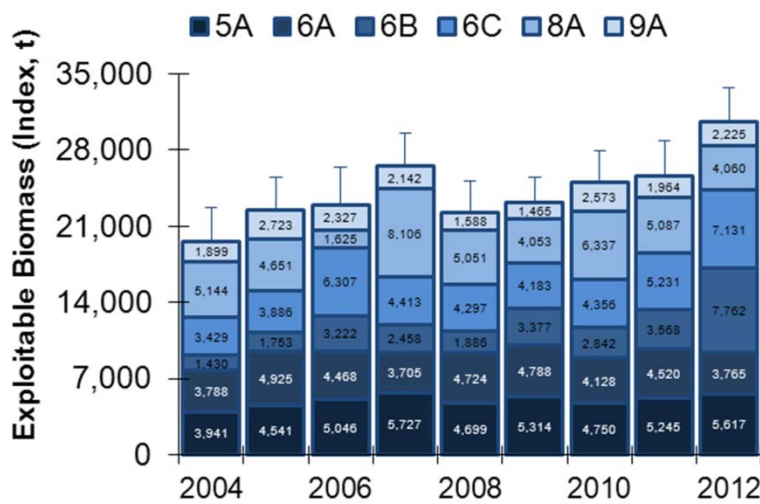


Figure 163: Exploitable biomass indices by crab management area from the CPS trap survey in Division 3L inshore.

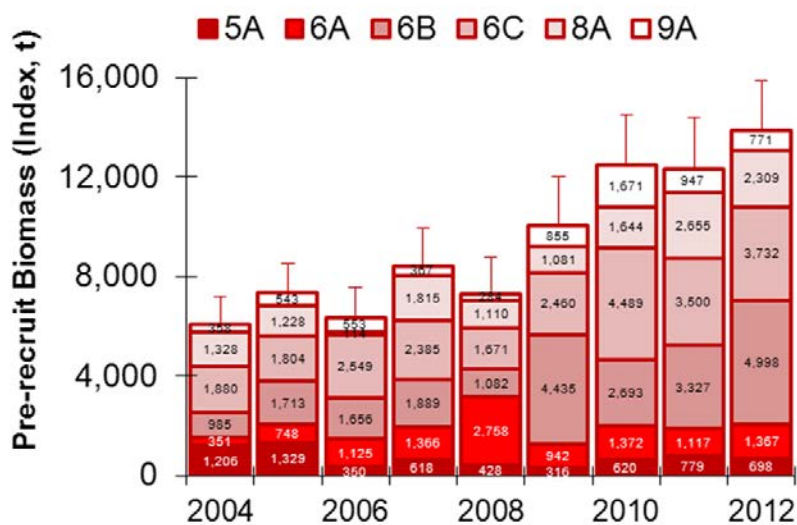


Figure 164: Pre-recruit biomass indices by crab management area from the CPS trap survey in Division 3L inshore.

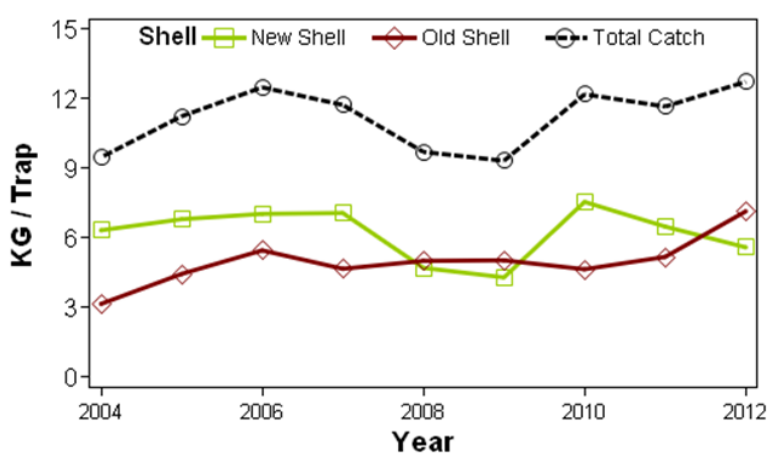


Figure 165: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in Div. 3L inshore.

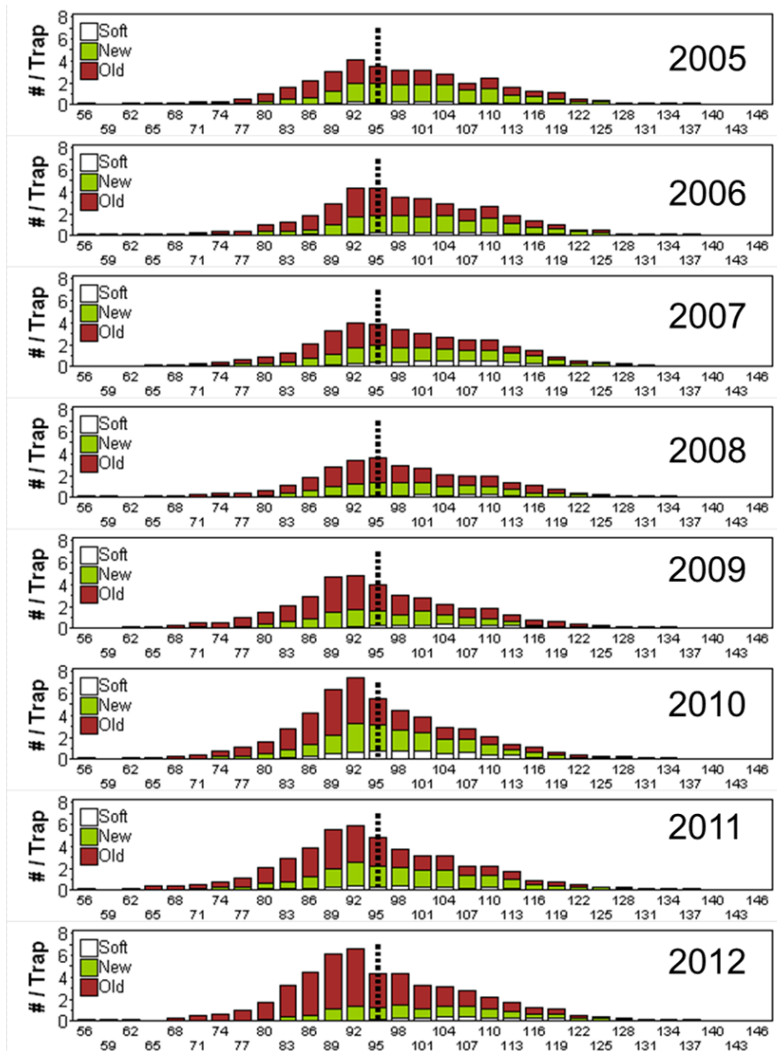


Figure 166: Trends in male carapace width distributions from core stations in the Div. 3L inshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

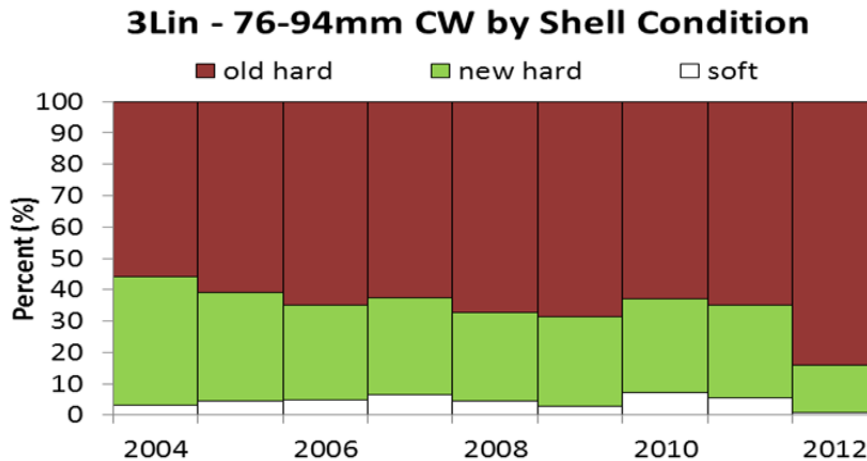


Figure 167: Trends in shell condition of 76-94mm CW crabs from the Div. 3L inshore CPS trap survey.

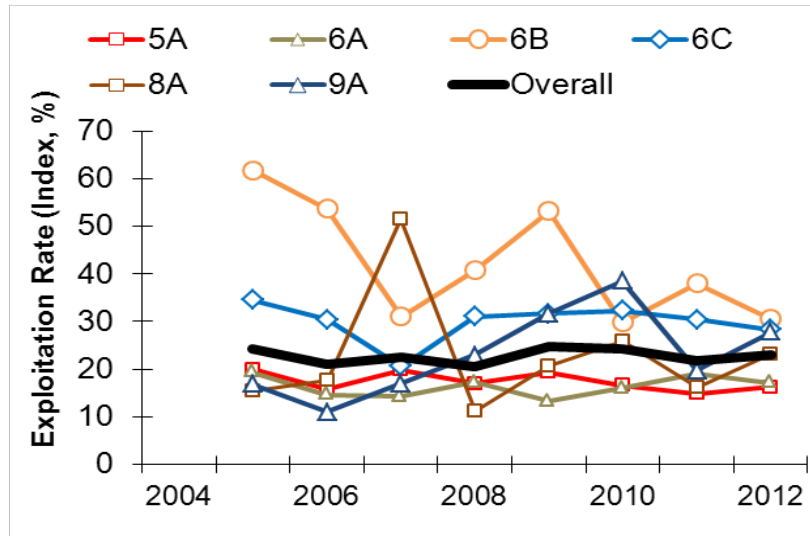


Figure 168: Exploitation rate indices by crab management area as well as overall for Div. 3L inshore based on the CPS trap survey.

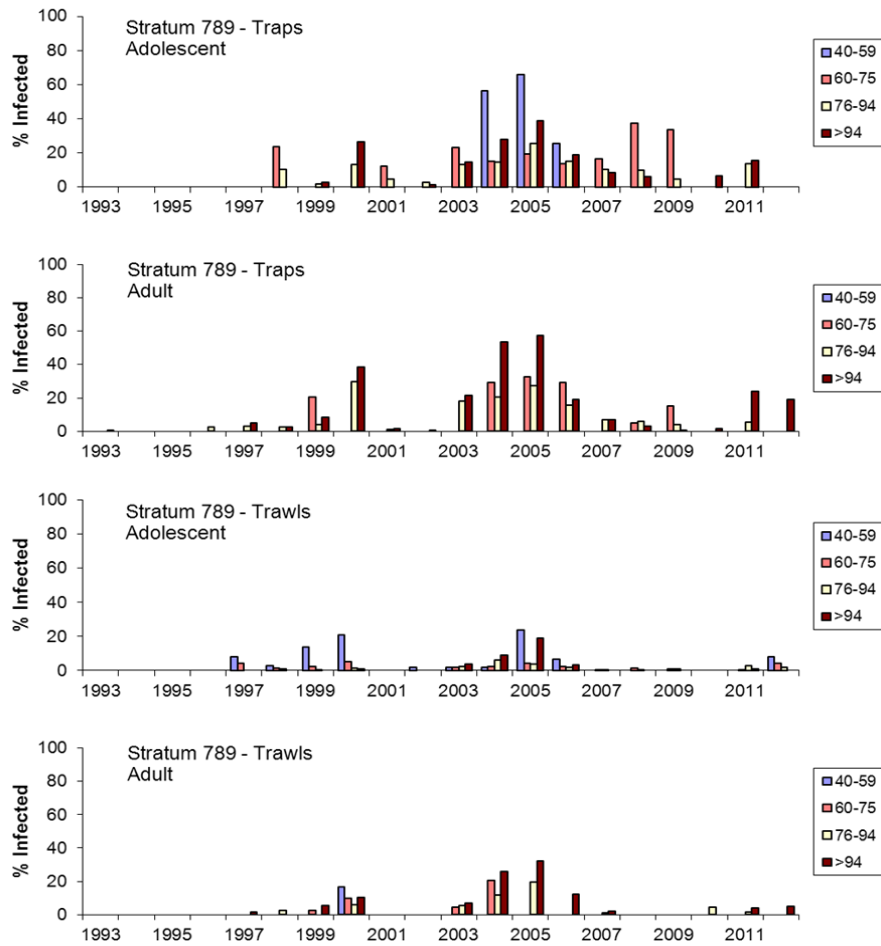


Fig. 169: Trends in prevalence of BCD in new-shelled adolescent vs. adult males by year and size group in stratum 789 from Conception Bay trap surveys (above) and trawl surveys (below)

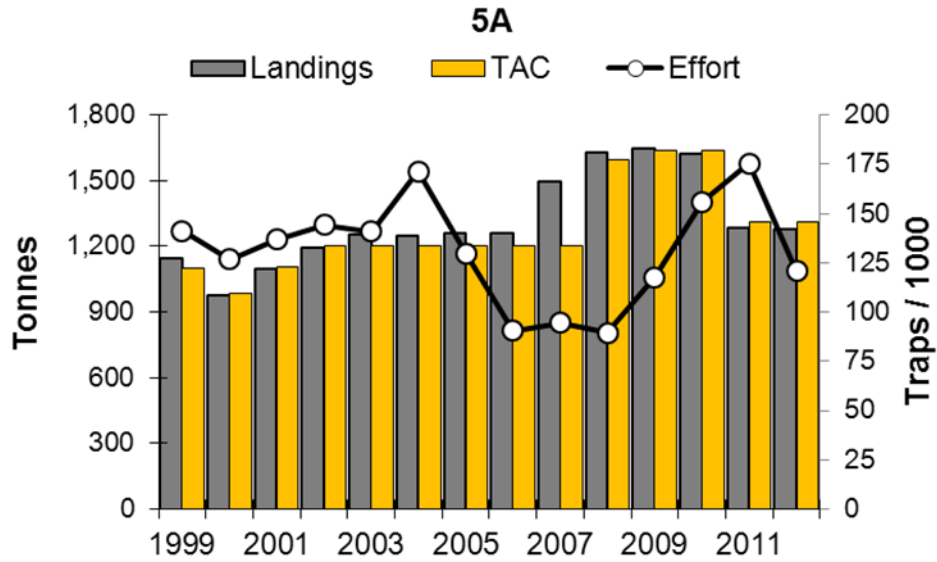


Figure 170: Trends in CMA 5A landings, TAC, and fishing effort.

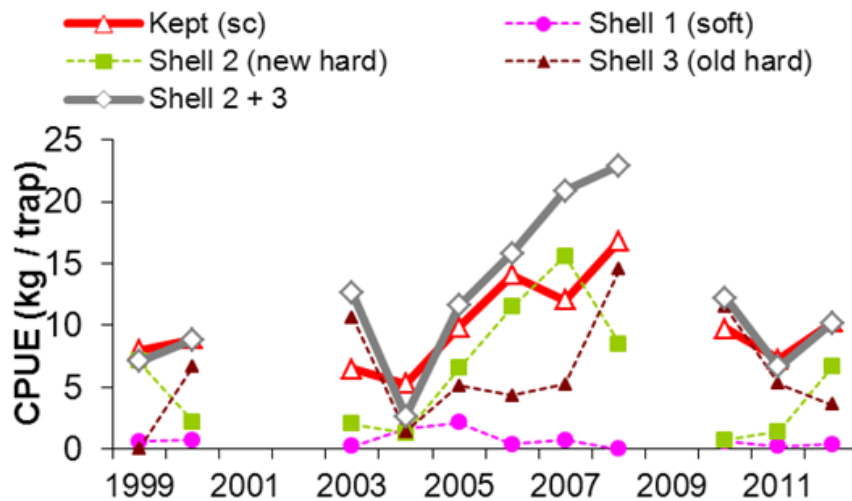


Figure 171: Trends in CMA 5A observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

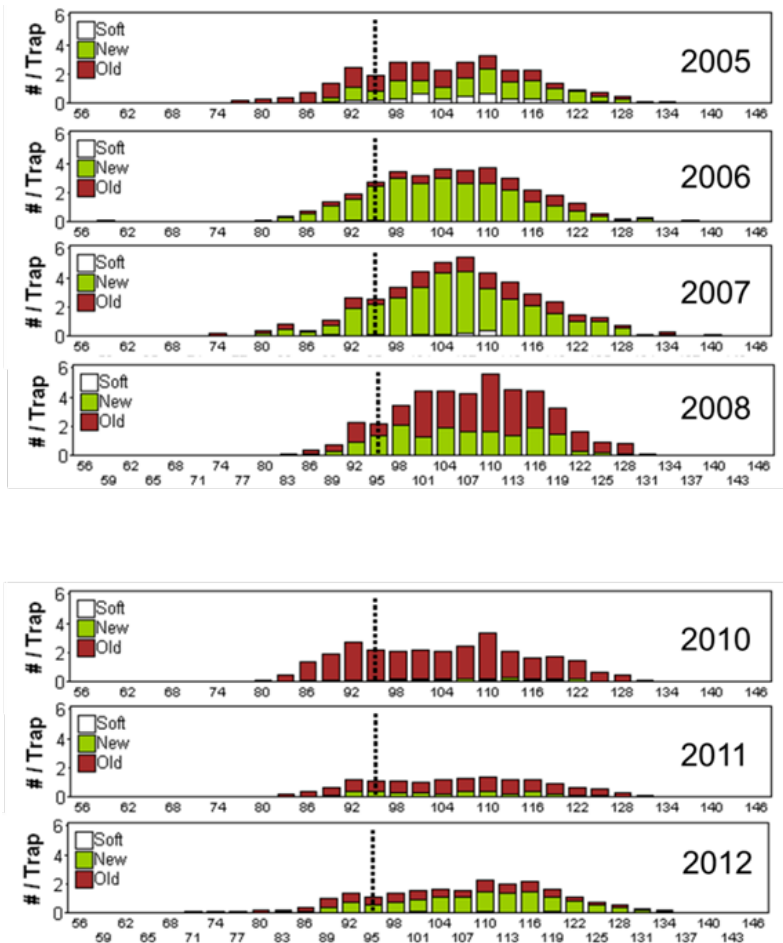


Figure 172: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 5A. The vertical dashed line indicates the minimum legal size.

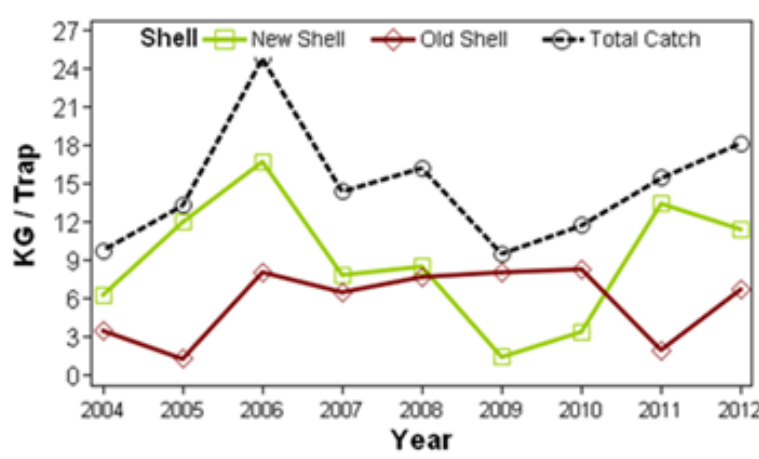


Figure 173: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 5A.

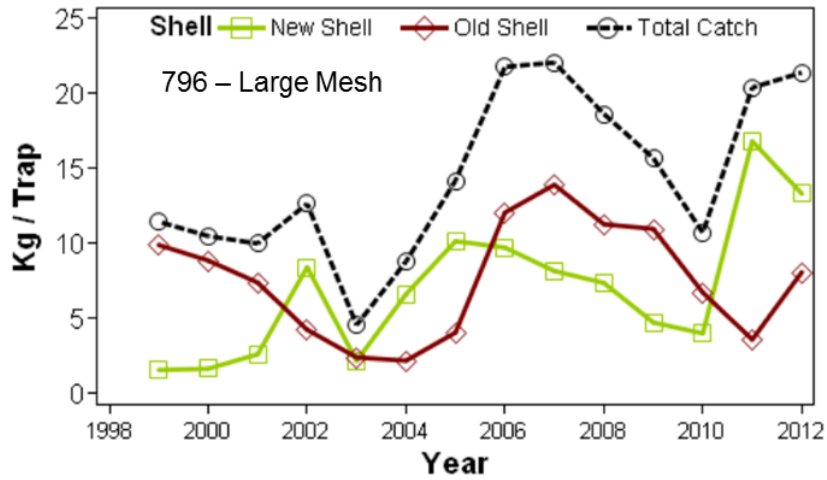


Figure 174: Trends in CPUE by shell condition for legal-sized crabs from the stratum occupied in the DFO trap survey in Bonavista Bay.

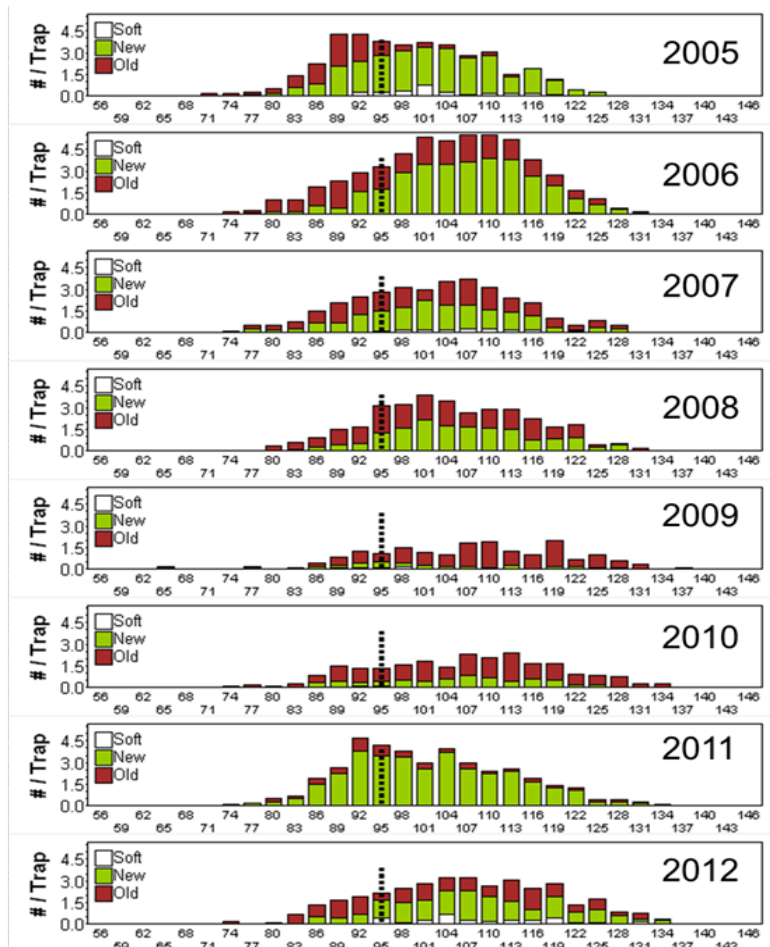


Figure 175: Trends in male carapace width distributions from core stations in CMA 5A from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

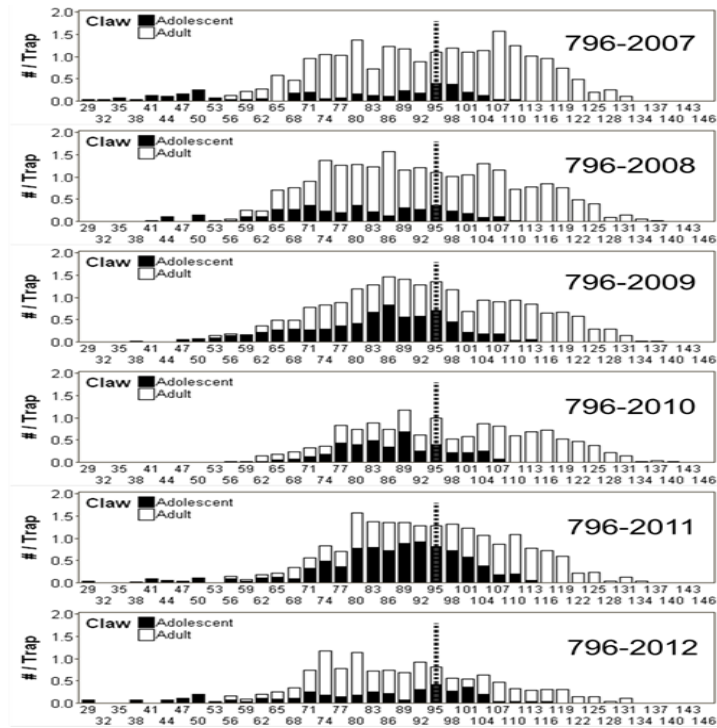


Figure 176: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-meshed traps in the DFO trap survey in Bonavista Bay. The vertical dashed line indicates the minimum legal size.

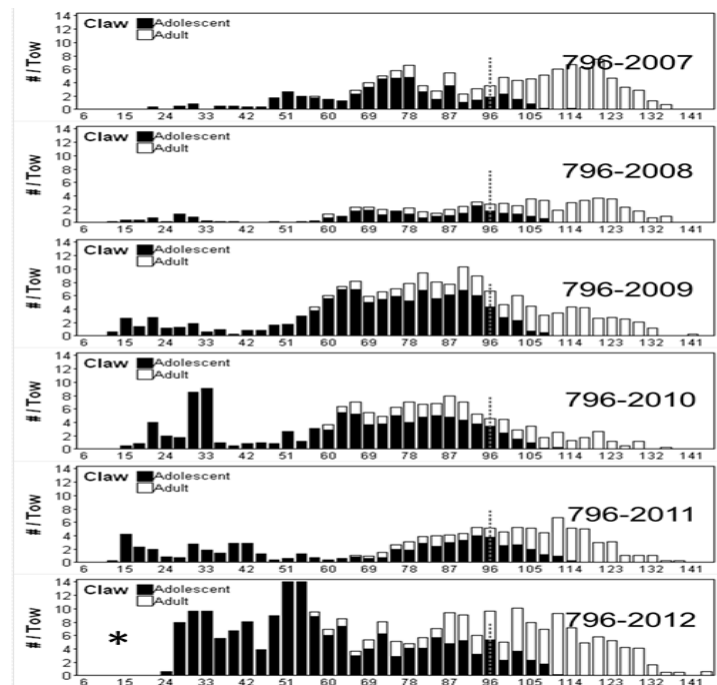


Figure 177: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from the DFO trawl survey in Bonavista Bay. The vertical dashed line indicates the minimum legal size.

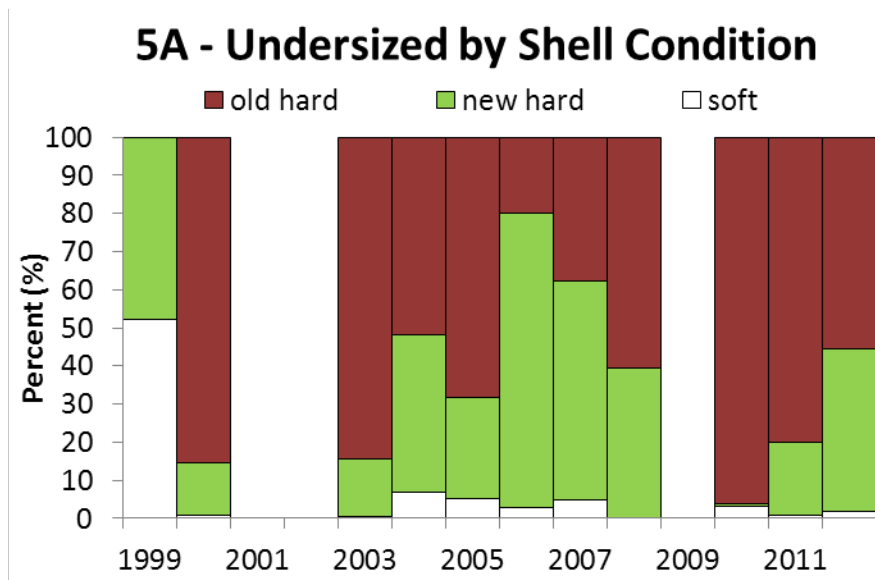


Figure 178: Trends in shell condition of 76-94mm CW crabs from CMA 5A observer sampling.

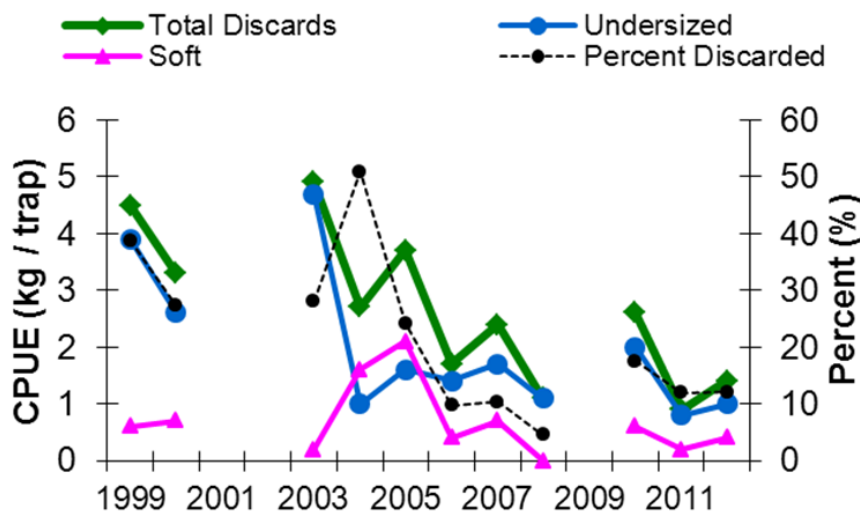


Figure 179: Trends in CMA 5A observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

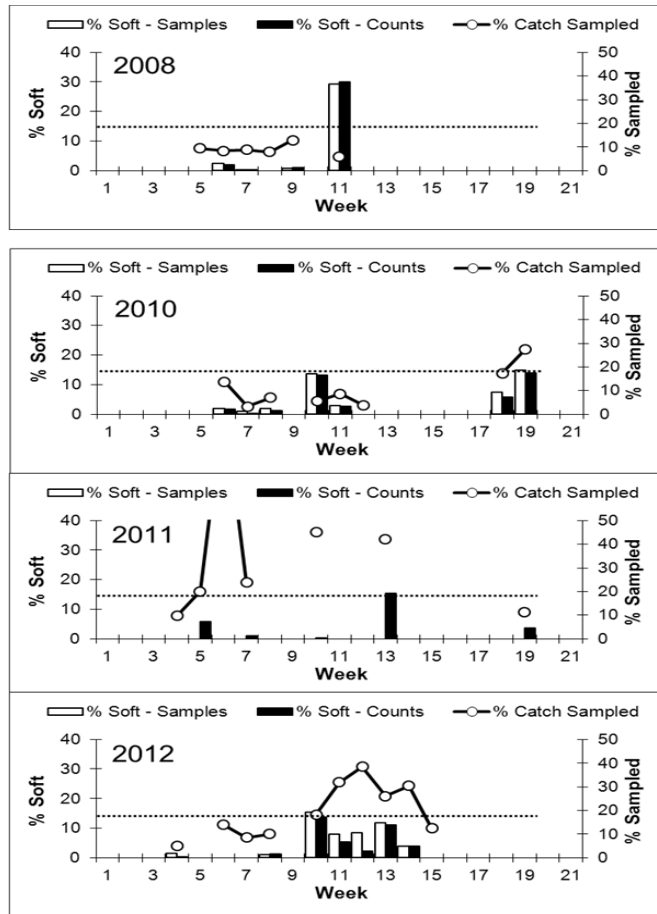


Figure 180: Trends in weekly percentages of soft-shell crab in CMA 5A from at-sea sampling by observers.

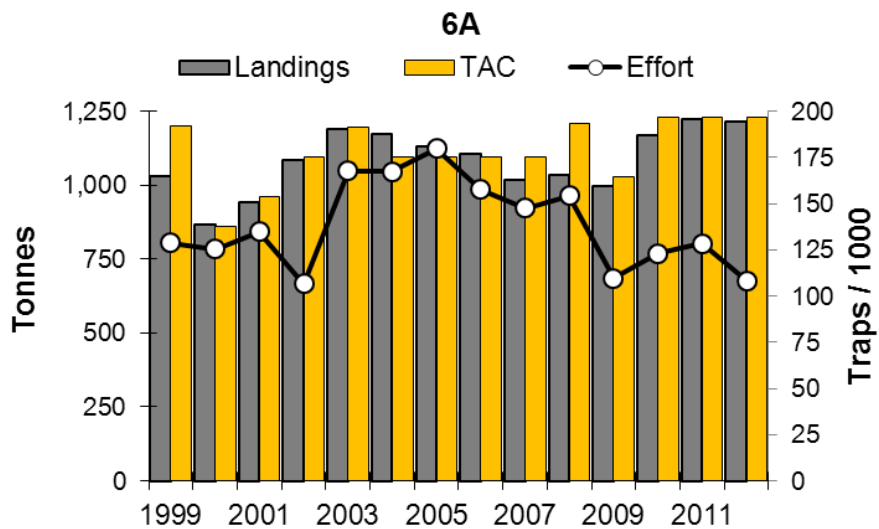


Figure 181: Trends in CMA 6A landings, TAC, and fishing effort.

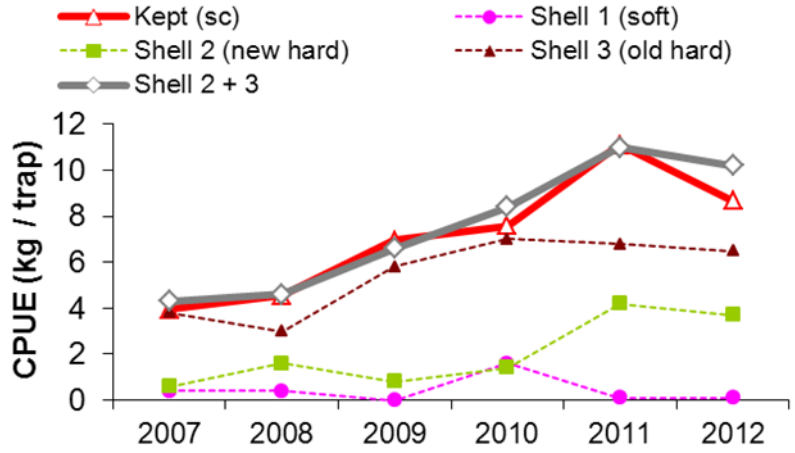


Figure 182: Trends in CMA 6A observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

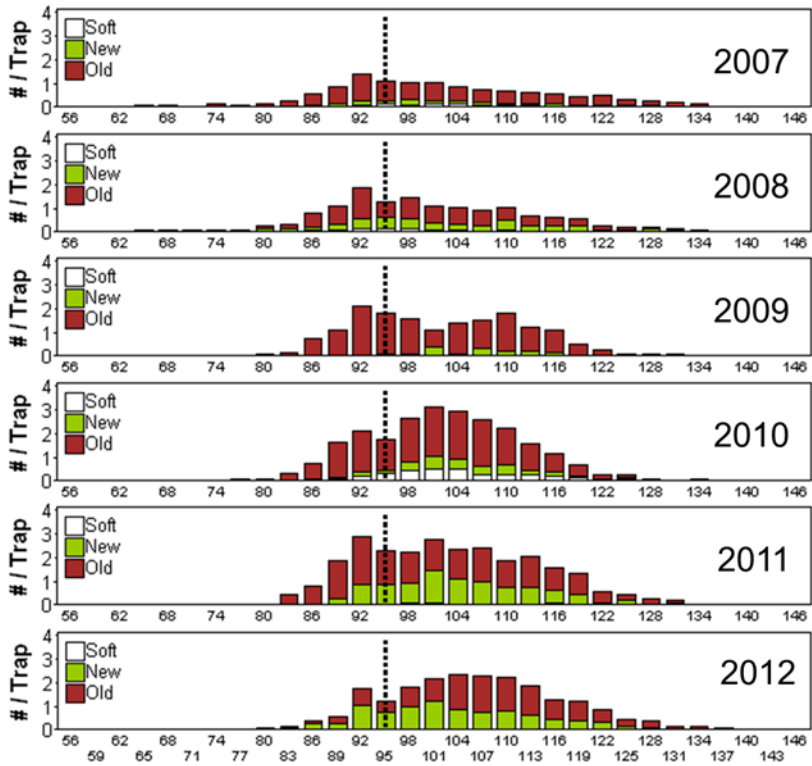


Figure 183: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 6A. The vertical dashed line indicates the minimum legal size.

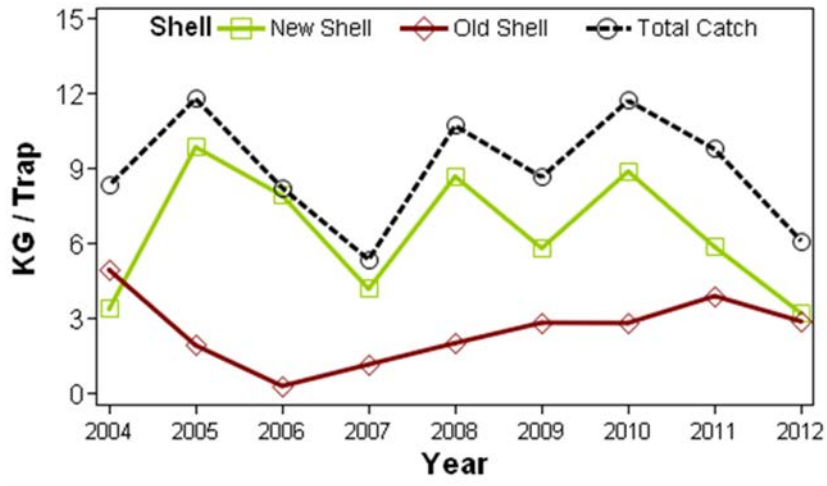


Figure 184: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 6A.

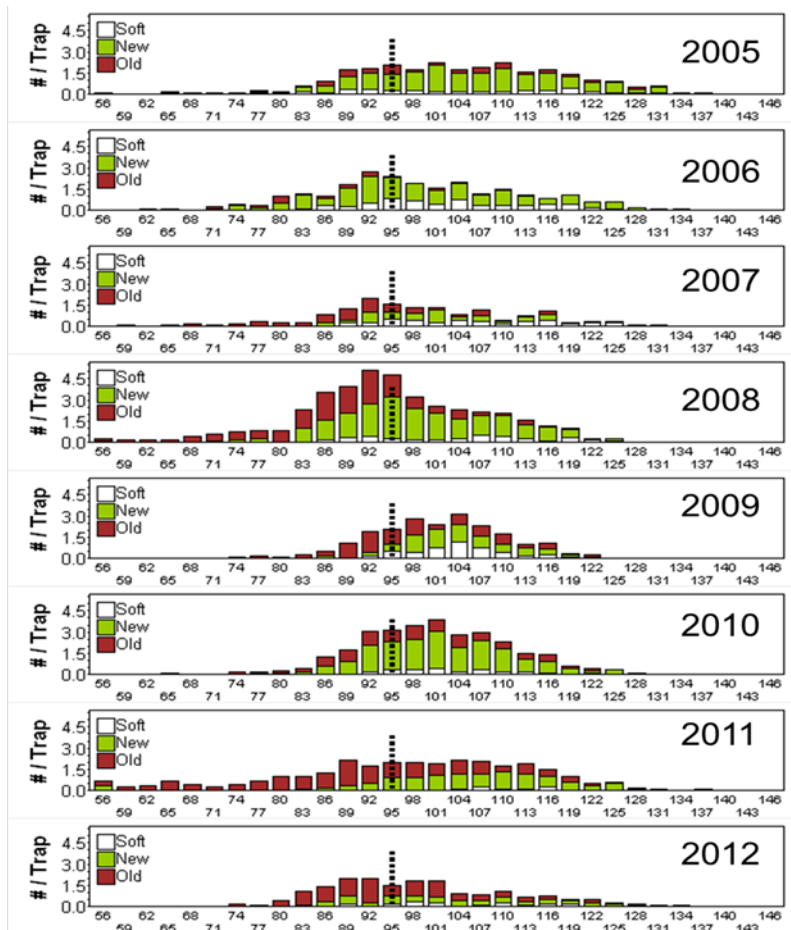


Figure 185: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 6A. The vertical dashed line indicates the minimum legal size.

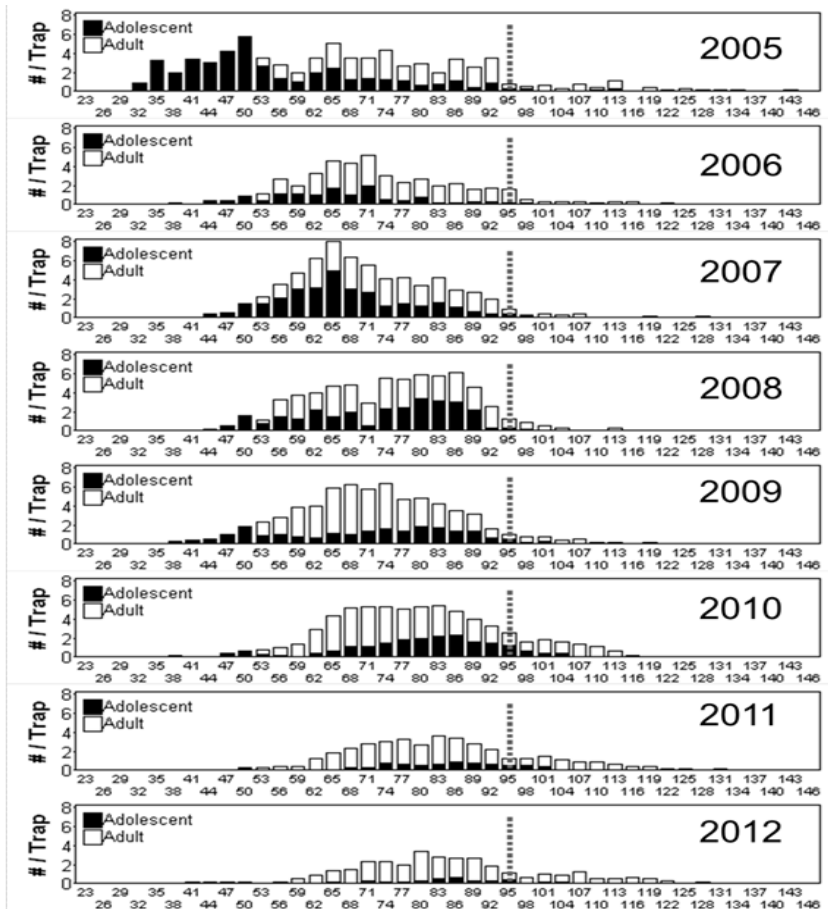


Figure 186: Trends in male carapace width distributions from small-mesh traps in CMA 6A from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

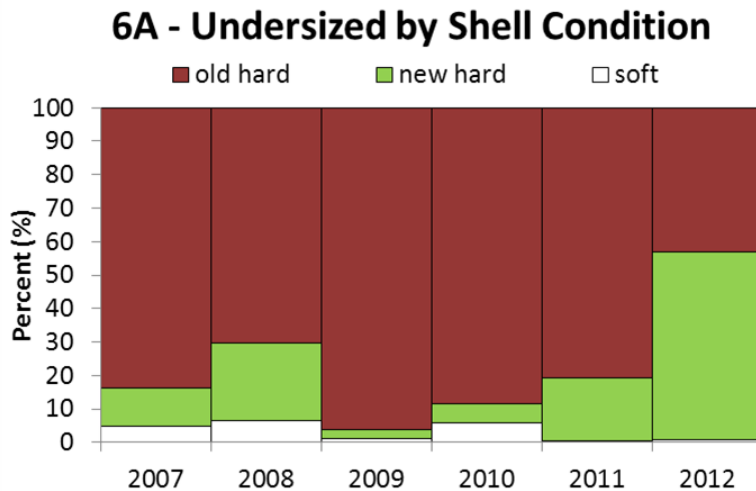


Figure 187: Trends in shell condition of 76-94mm CW crabs from CMA 6A observer sampling.

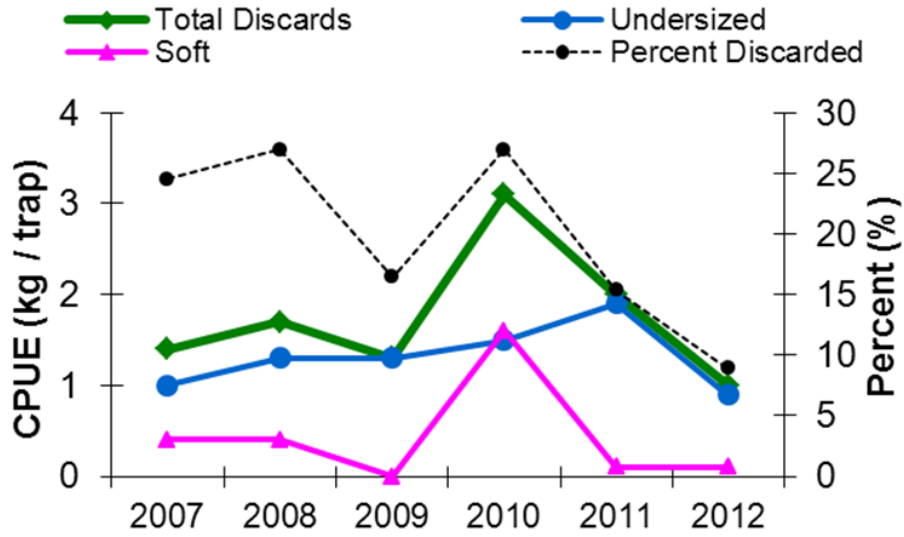


Figure 188: Trends in CMA 6A observer catch rates of total discards, undersized discards, and legalized soft-shelled discards, as well as the percentage of the catch discarded.

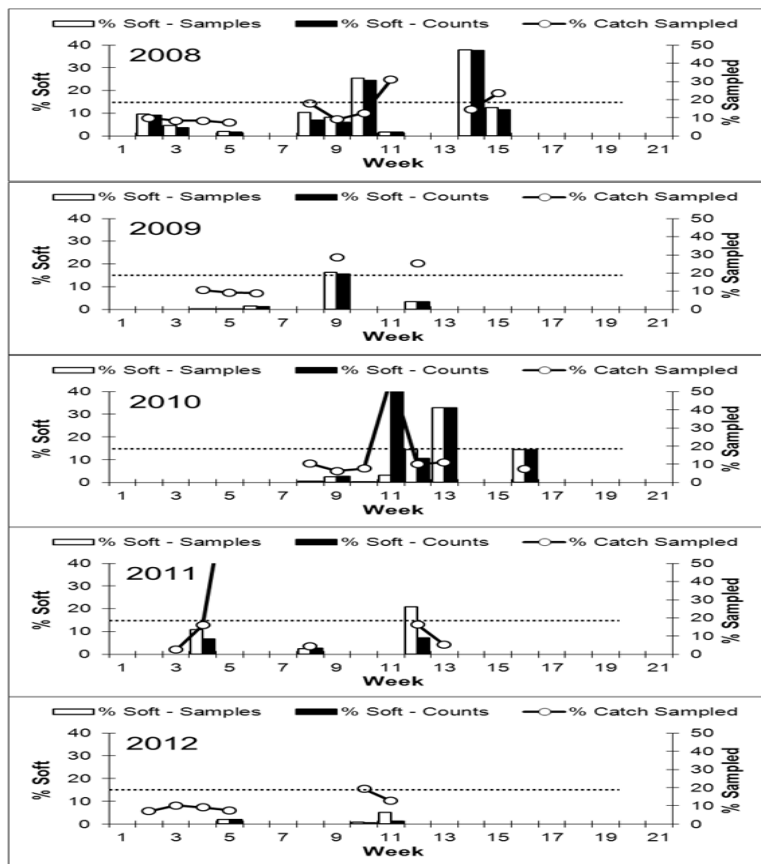


Figure 189: Trends in weekly percentages of soft-shell crab in CMA 6A from at-sea sampling by observers.

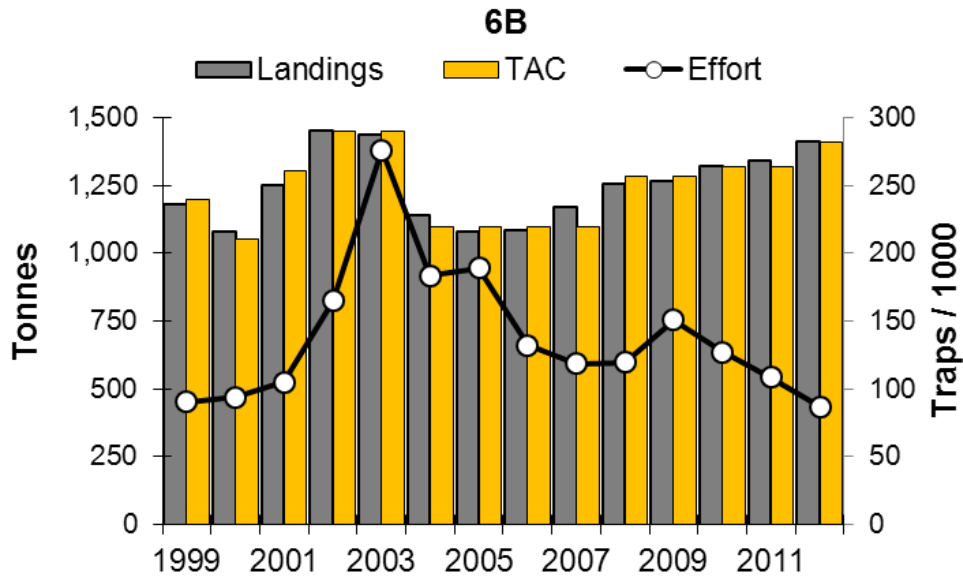


Figure 190: Trends in CMA 6B landings, TAC, and fishing effort.

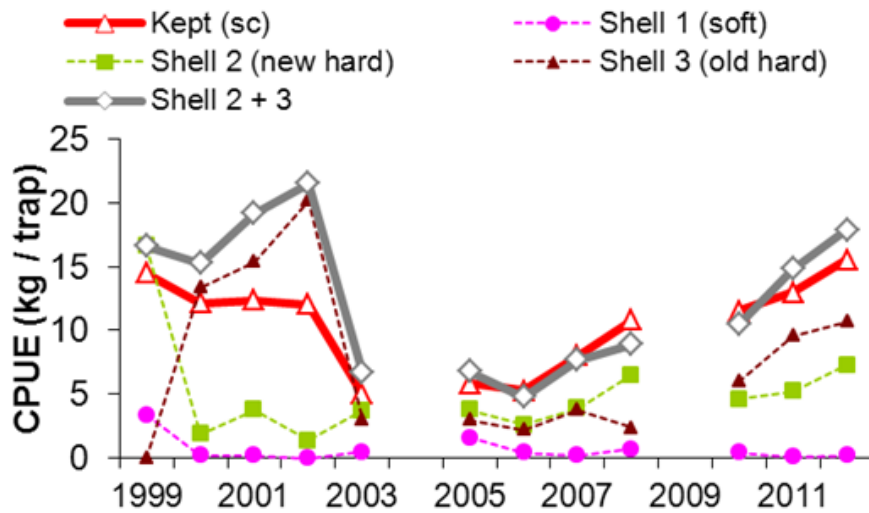


Figure 191: Trends in CMA 6B observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

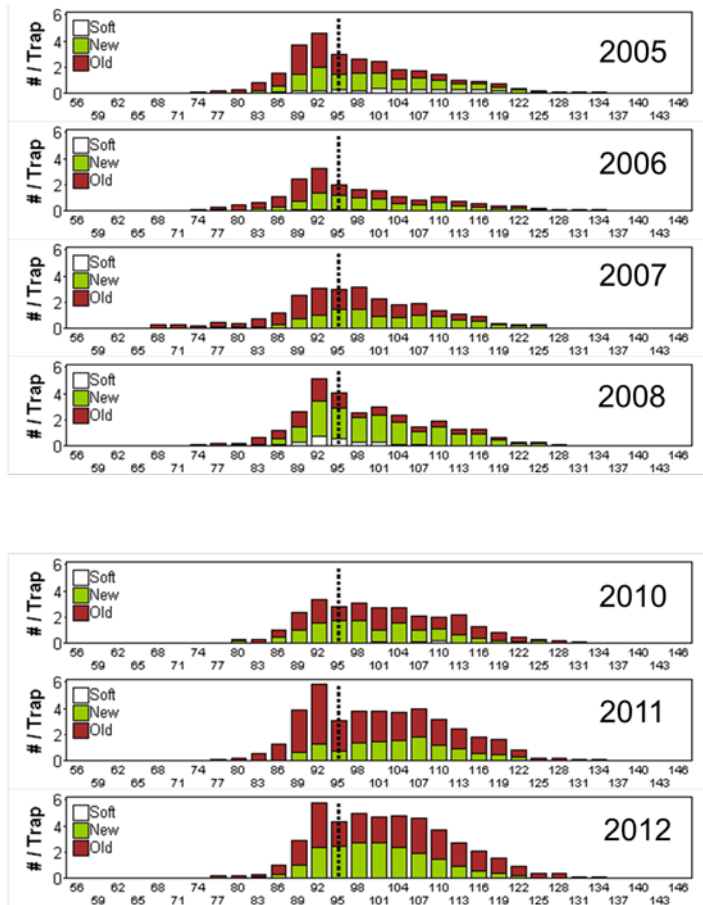


Figure 192: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 6B. The vertical dashed line indicates the minimum legal size.

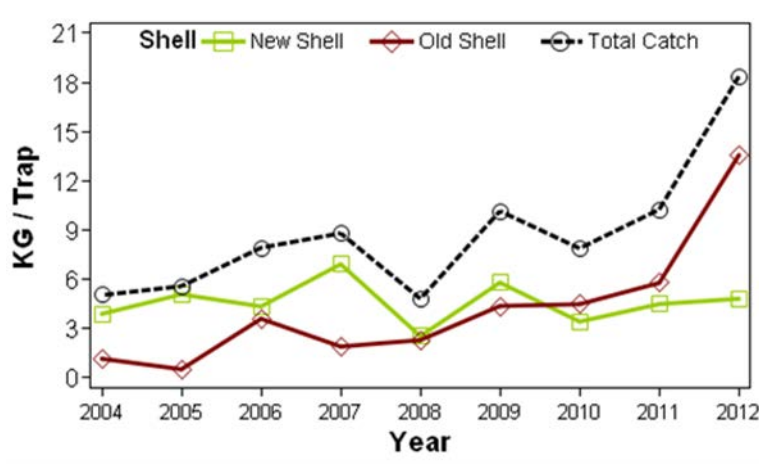


Figure 193: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 6B.

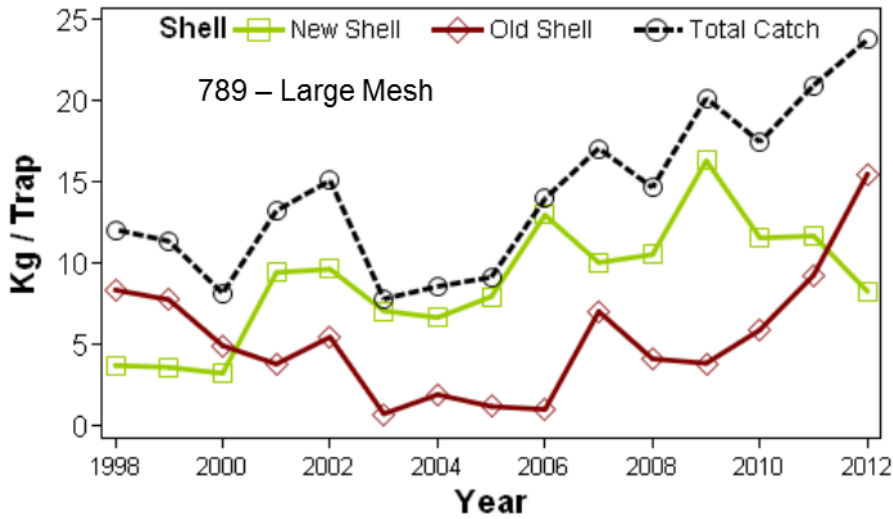


Figure 194: Trends in CPUE by shell condition for legal-sized crabs from the stratum occupied in the DFO trap survey in Conception Bay.

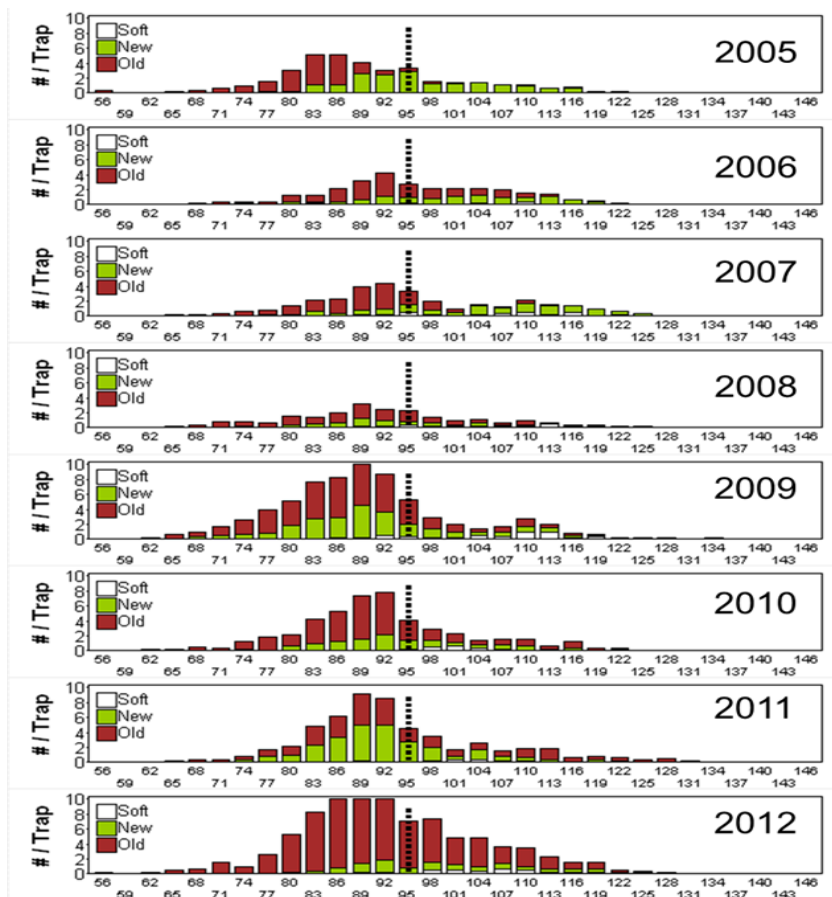


Figure 195: Trends in male carapace width distributions from core stations in CMA 6B from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

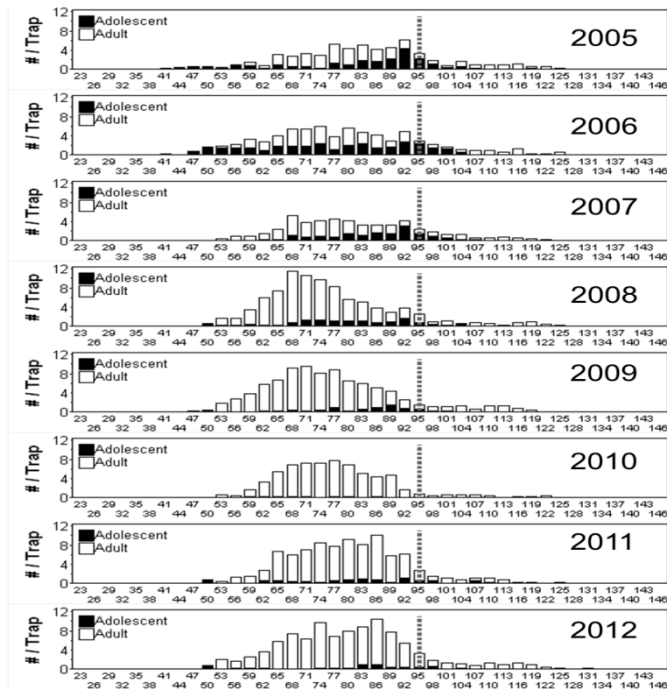


Figure 196: Trends in male carapace width distributions from small-mesh traps in CMA 6B from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

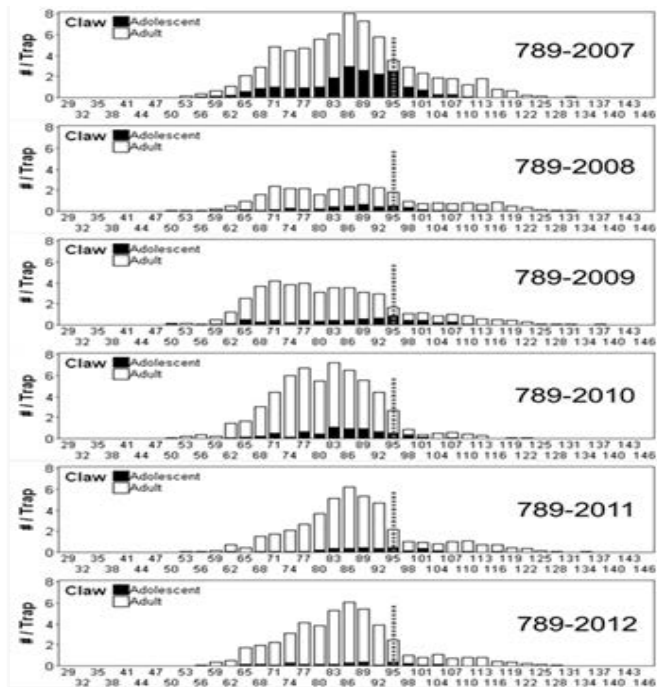


Figure 197: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in the DFO trap survey in Conception Bay.

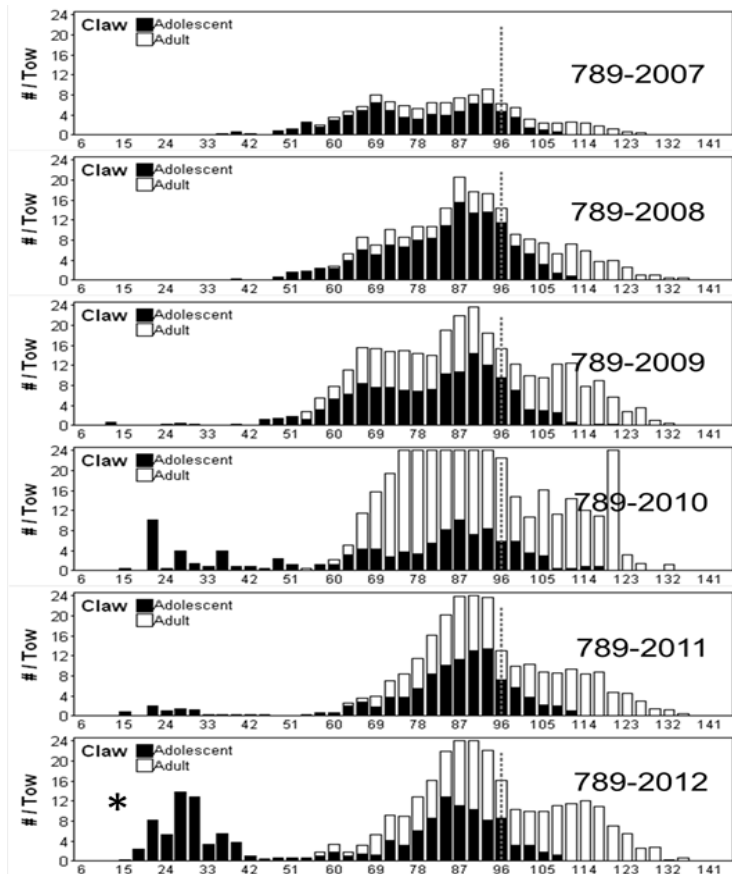


Figure 198: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from the DFO trawl survey in Conception Bay. The vertical dashed line indicates the minimum legal size.

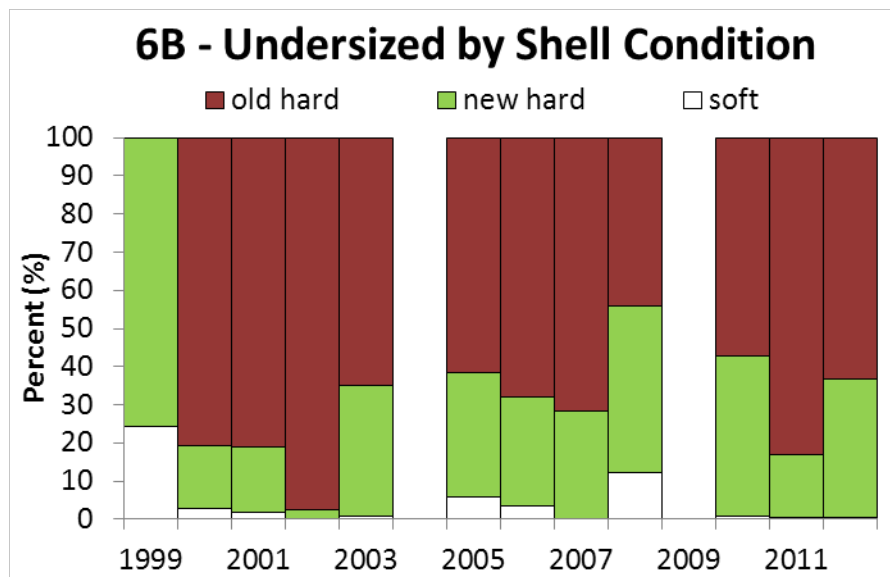


Figure 199: Trends in shell condition of 76-94mm CW crabs from CMA 6B observer sampling.

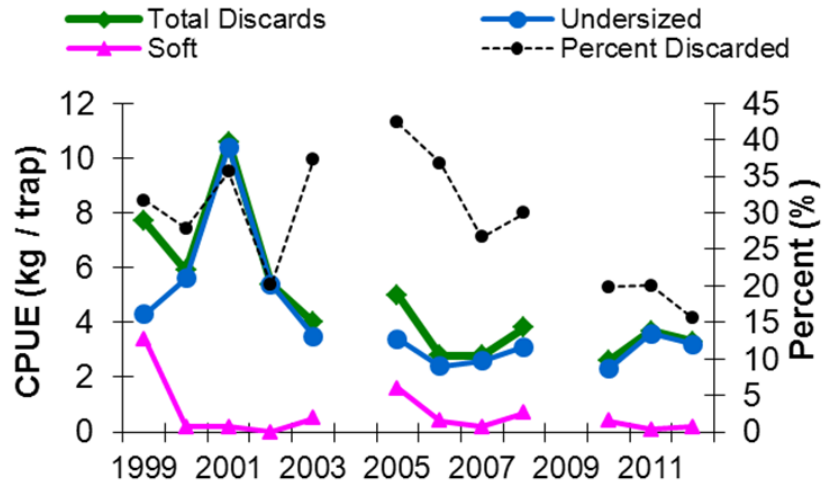


Figure 200: Trends in CMA 6B observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

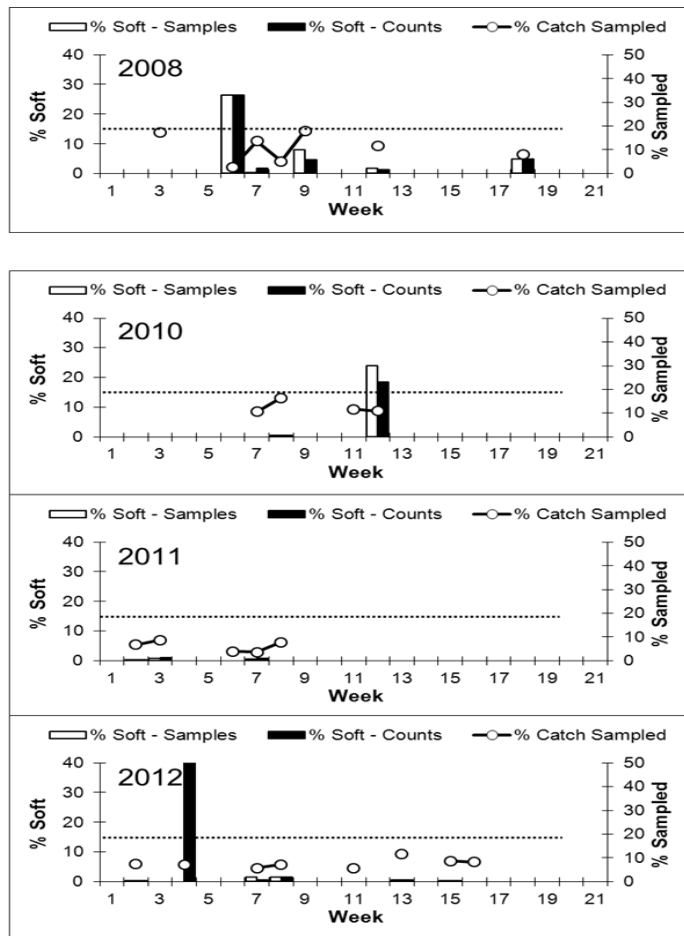


Figure 201: Trends in weekly percentages of soft-shell crab in CMA 6B from at-sea sampling by observers.

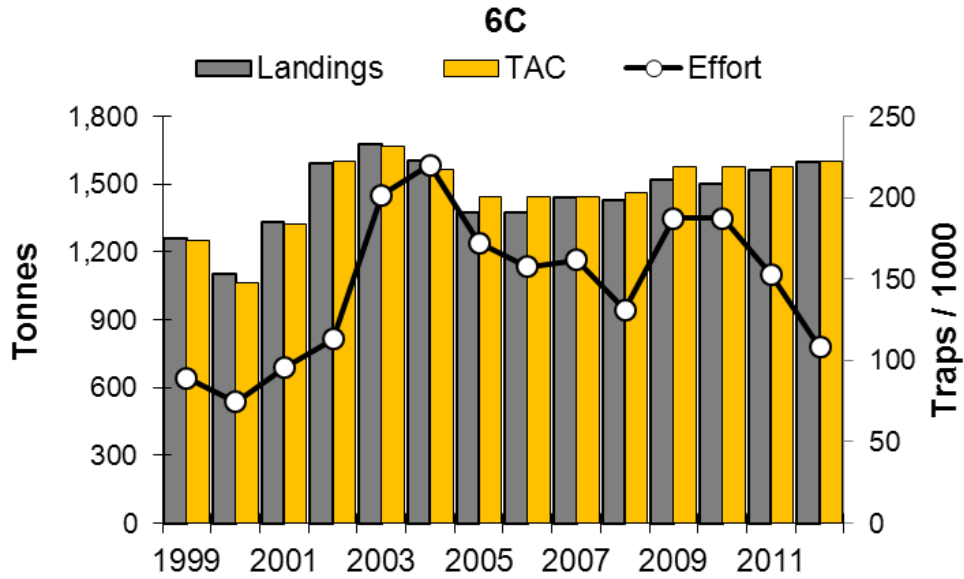


Figure 202: Trends in CMA 6C landings, TAC, and fishing effort.

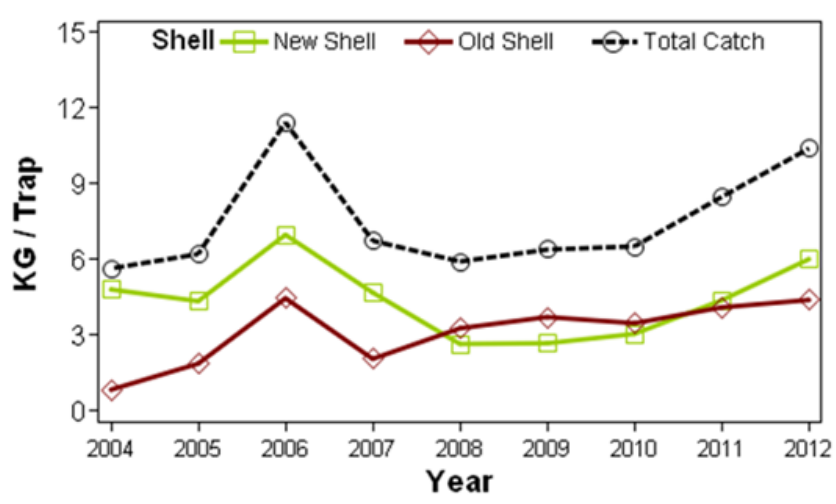


Figure 203: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 6C.

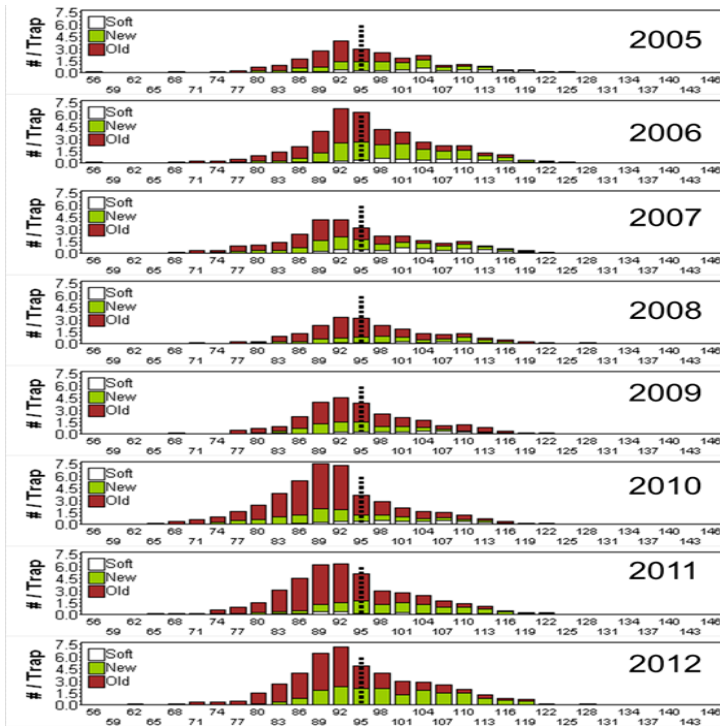


Figure 204: Trends in male carapace width distributions from core stations in CMA 6C from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

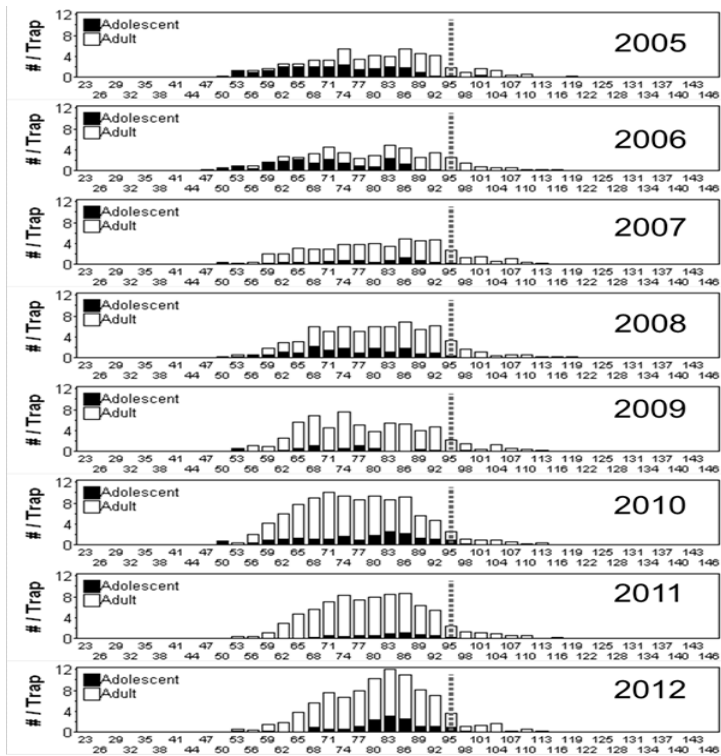


Figure 205: Trends in male carapace width distributions from small-mesh traps in CMA 6C from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

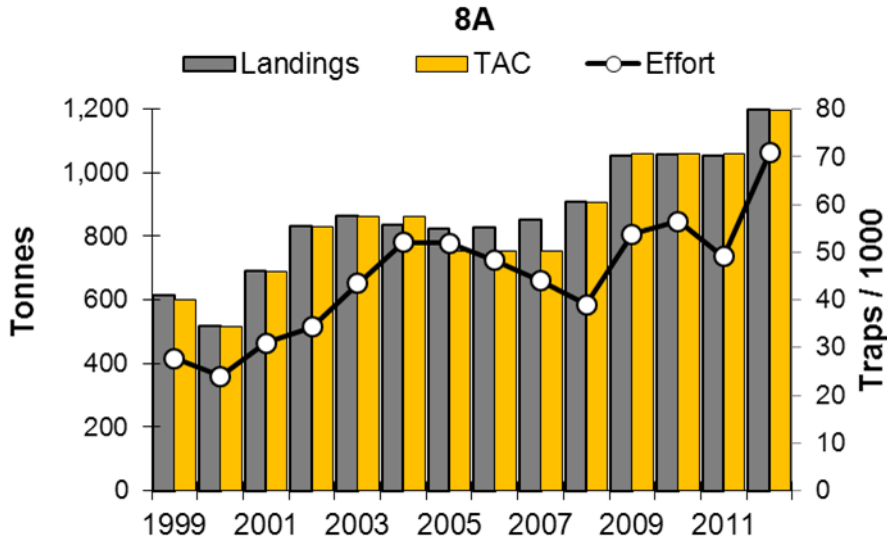


Figure 206: Trends in CMA 8A landings, TAC, and fishing effort.

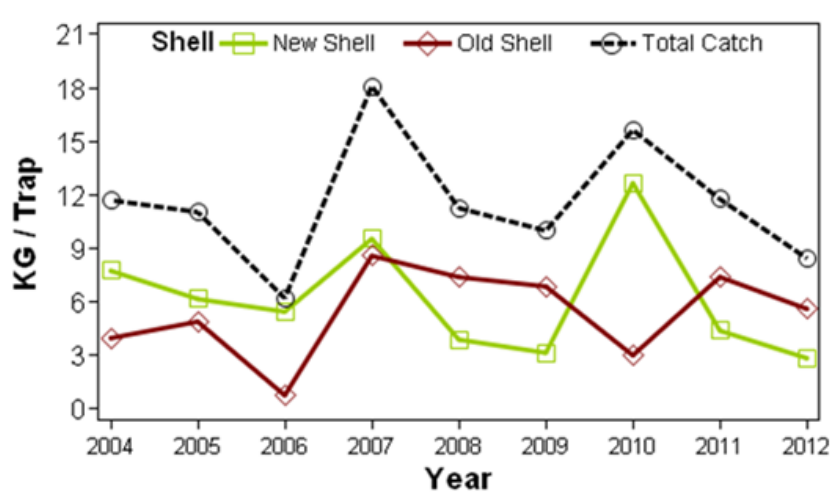


Figure 207: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 8A.

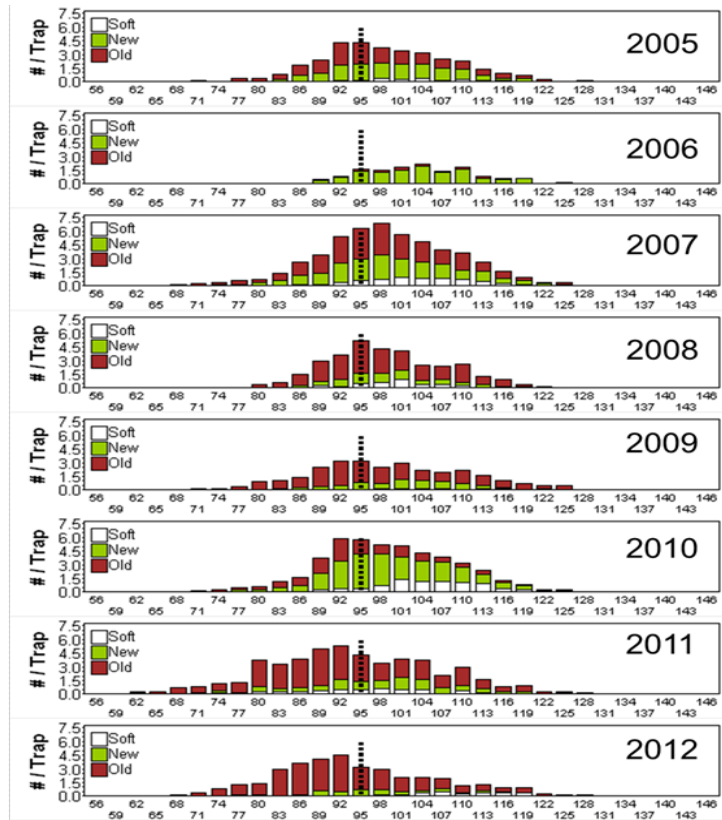


Figure 208: Trends in male carapace width distributions from core stations in CMA 8A from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

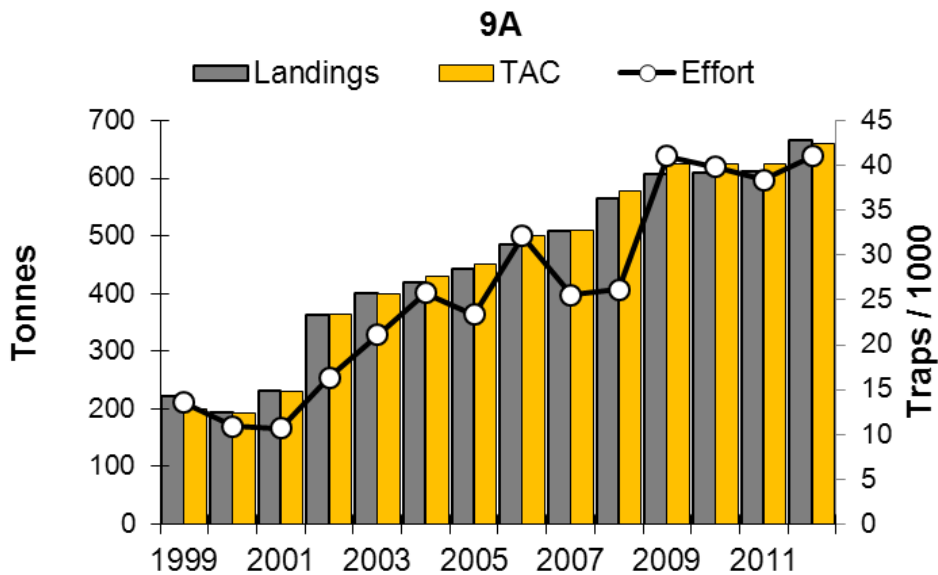


Figure 209: Trends in CMA 9A landings, TAC, and fishing effort.

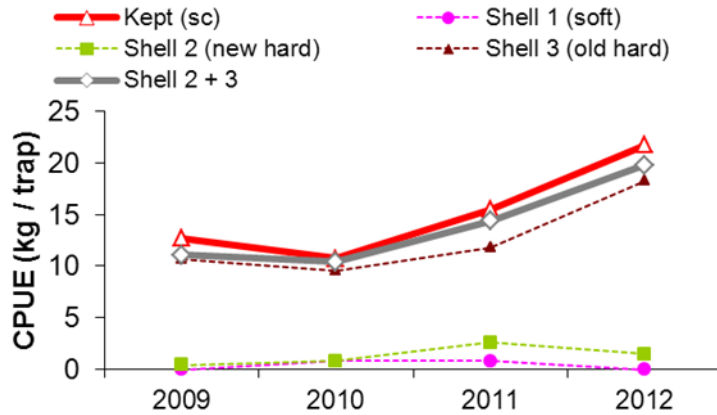


Figure 210: Trends in CMA 9A observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

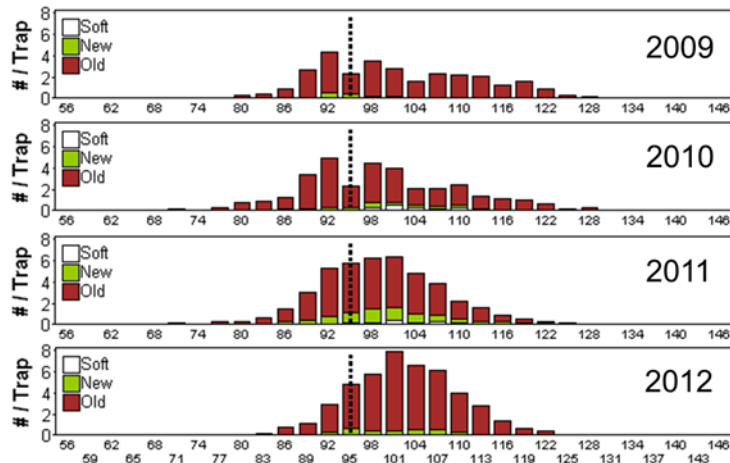


Figure 211: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 9A. The vertical dashed line indicates the minimum legal size.

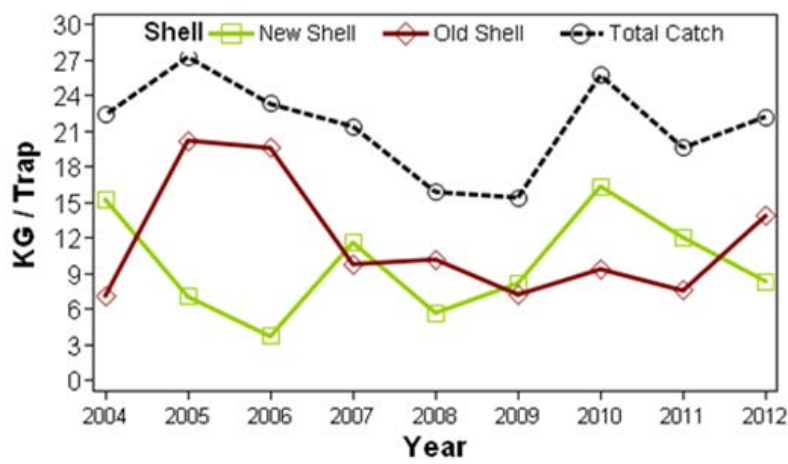


Figure 212: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 9A.

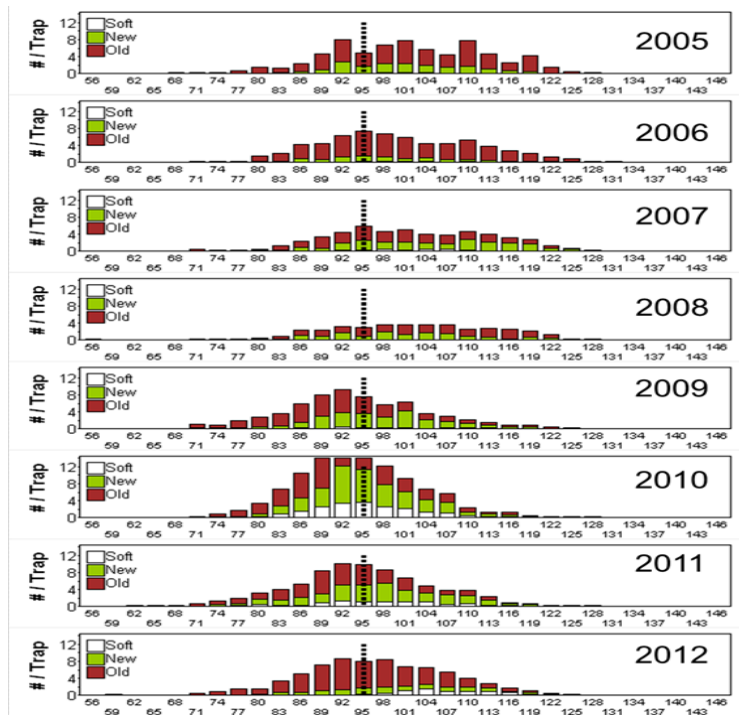


Figure 213: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 9A.

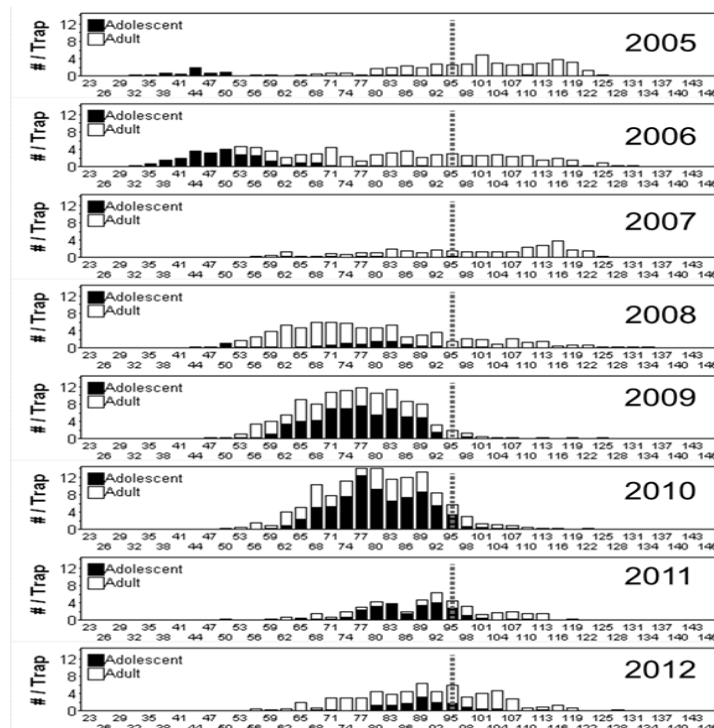


Figure 214: Trends in male carapace width distributions from small-mesh traps in CMA 9A from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

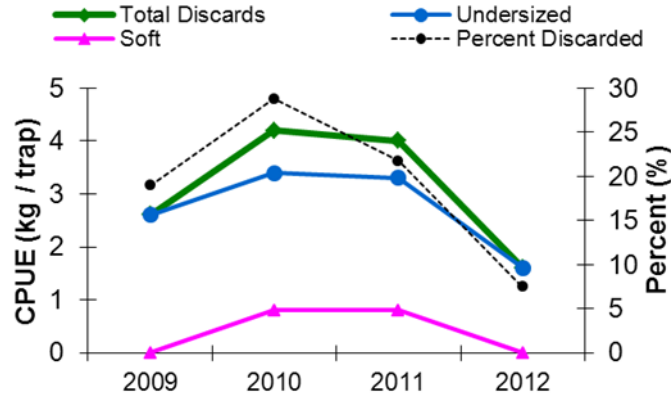


Figure 215: Trends in CMA 6B observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

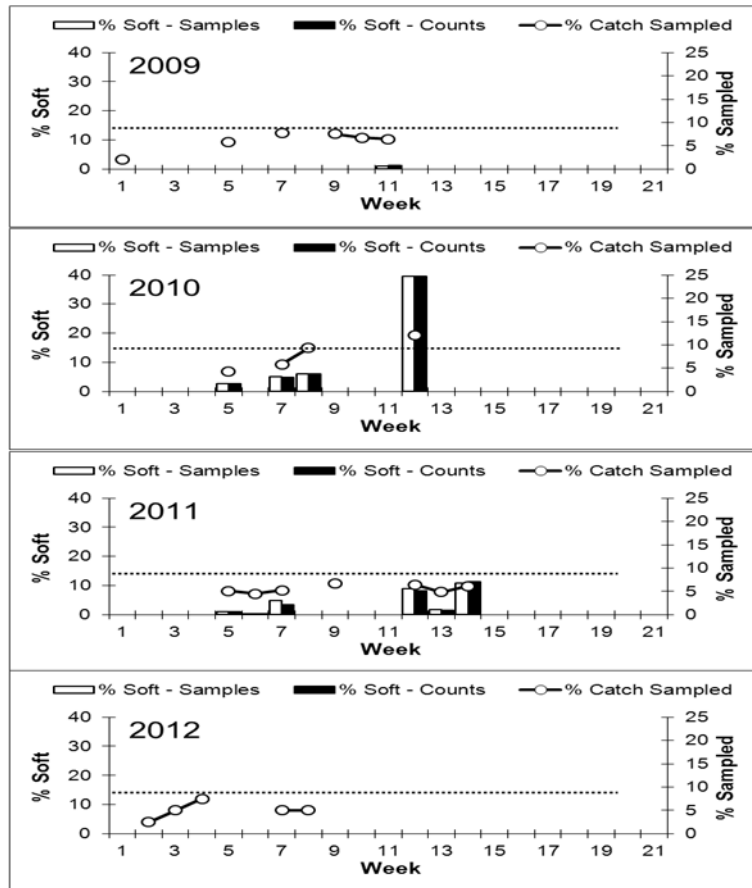


Figure 216: Trends in weekly percentages of soft-shell crab in CMA 9A from at-sea sampling by observers.

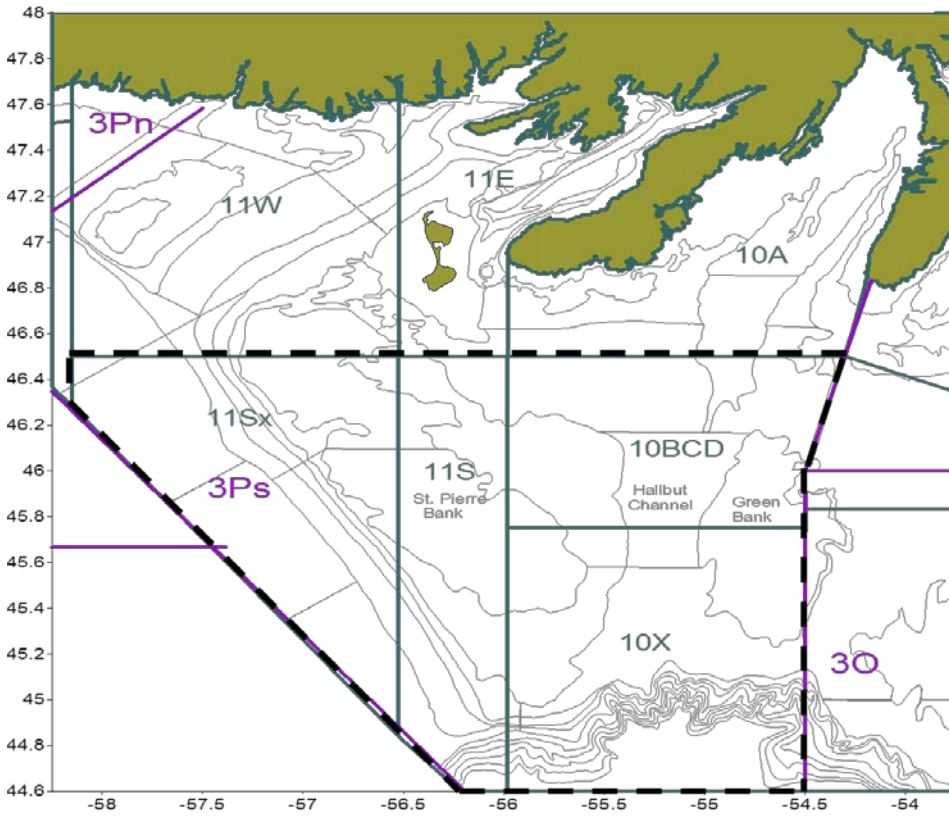


Figure 217: Map of Subdivision 3Ps showing crab management areas and important bathymetric features. Dashed perimeter indicates offshore areas.

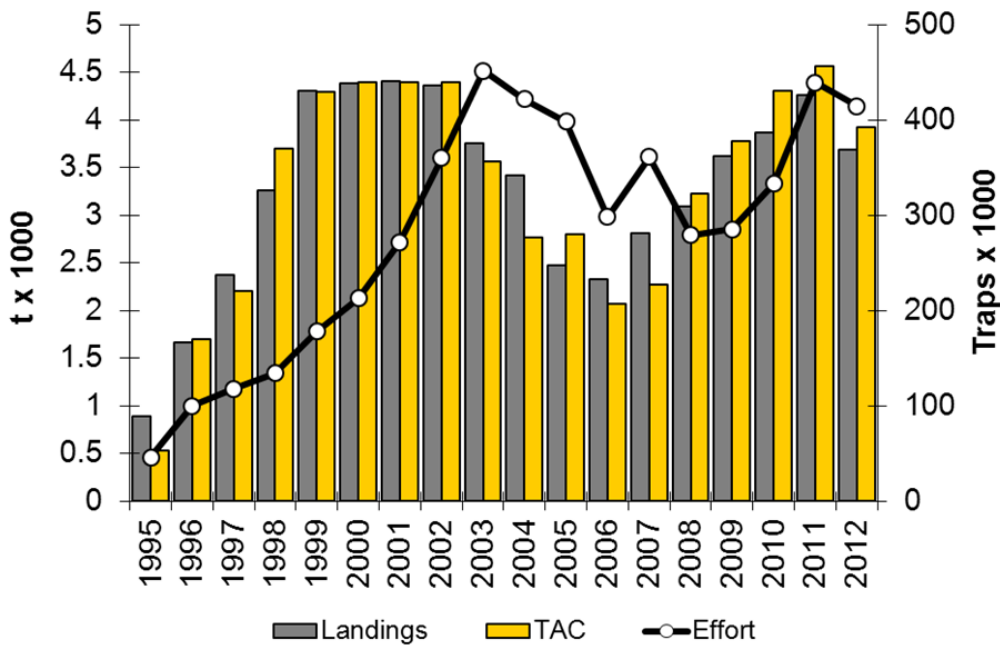


Figure 218: Trends in Subdiv. 3Ps offshore landings, TAC, and fishing effort.

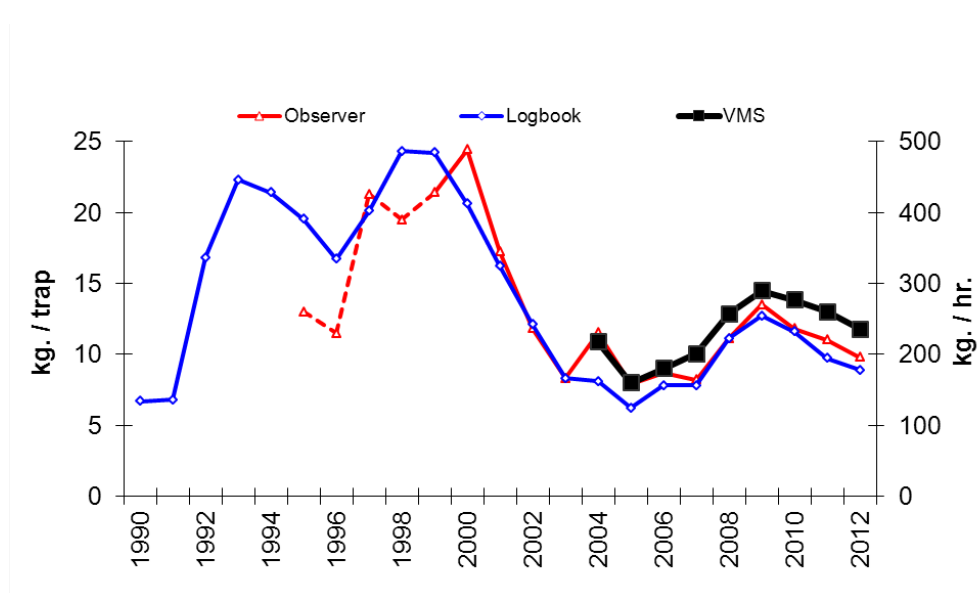


Figure 219: Trends in commercial logbook-based, observer-based, and VMS-based CPUE in the Subdiv. 3Ps offshore fishery. Solid black line denotes long-term VMS average.

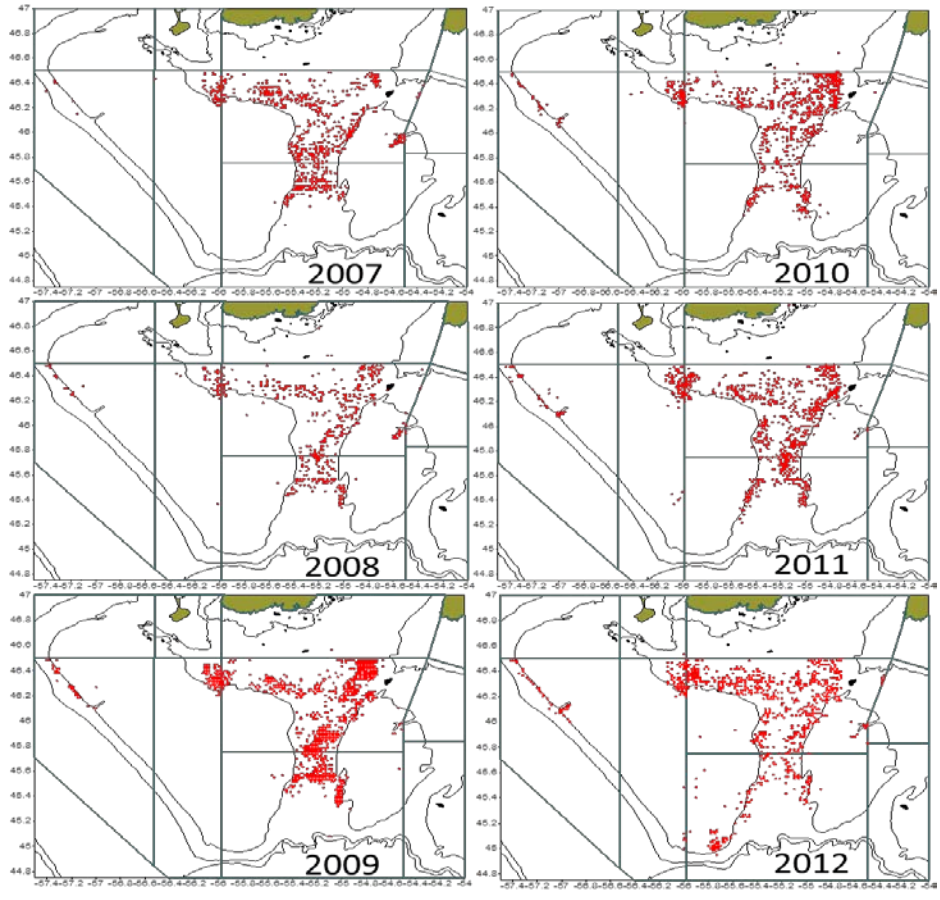


Figure 220: Spatial distribution of Subdiv. 3Ps fishing effort by year.

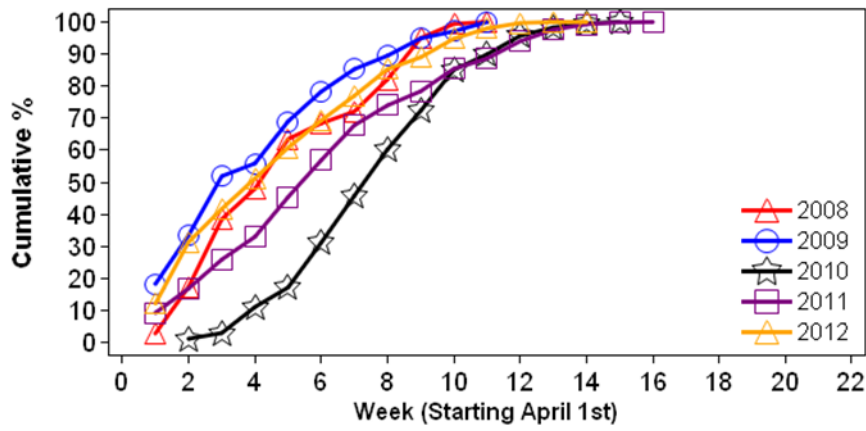


Figure 221: Seasonal trends in fishing effort for Subdiv. 3Ps offshore.

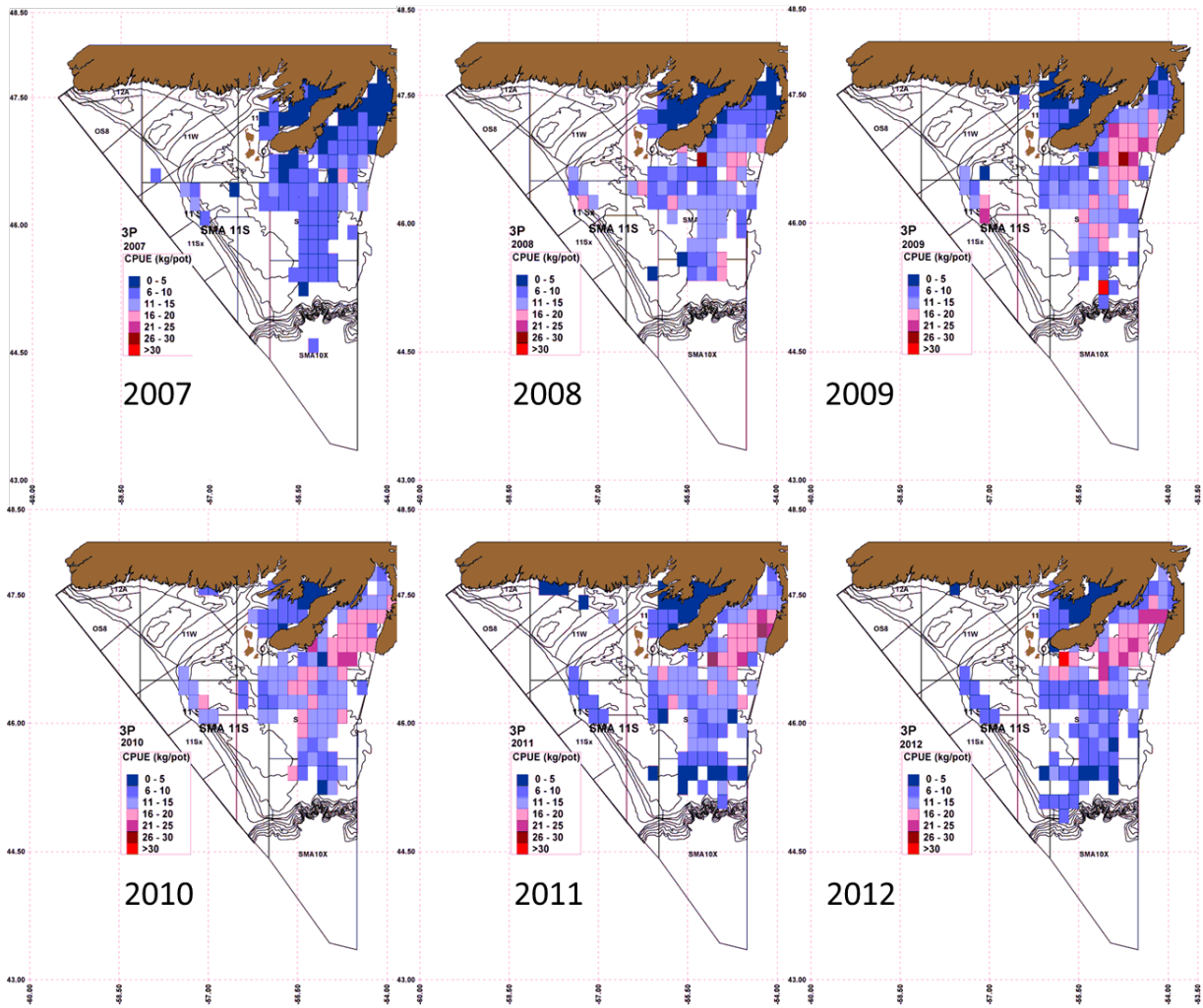


Figure 222: Spatial distribution of Subdiv. 3Ps offshore logbook CPUE by year.

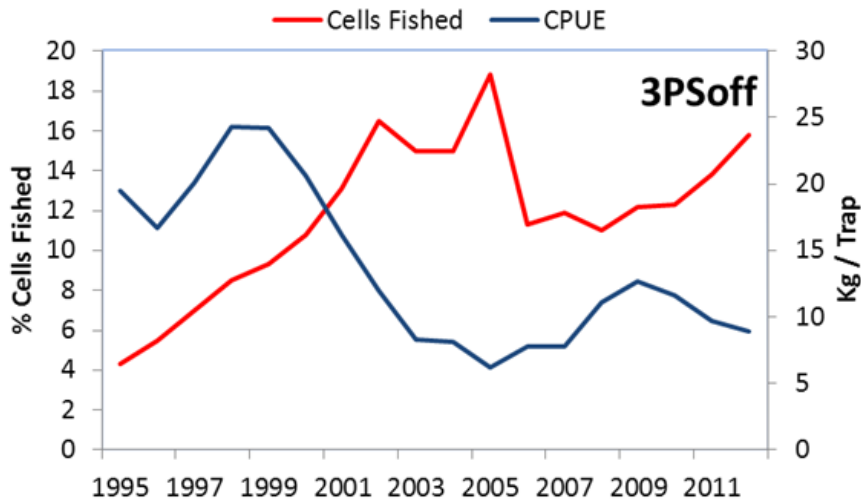


Figure 223: Trends in Subdiv. 3Ps offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

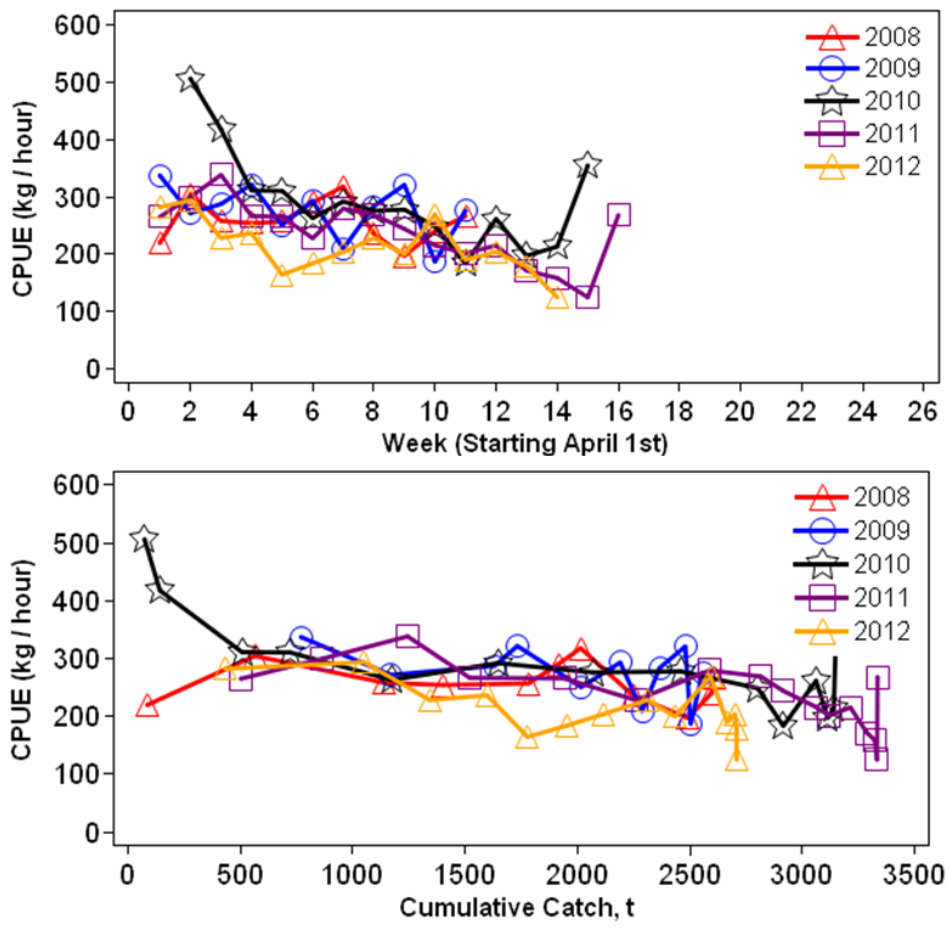


Figure 224: Seasonal trends in VMS-based CPUE for Subdiv. 3Ps offshore; by week (above), and in relation to cumulative catch (below).

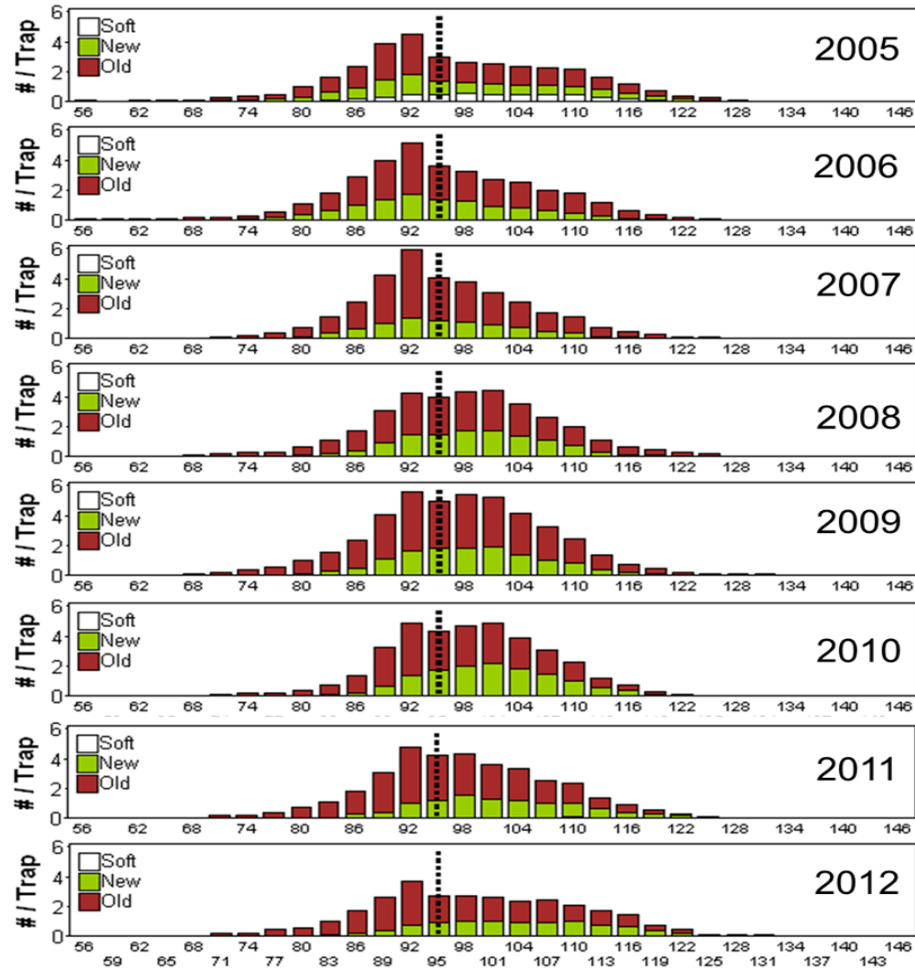


Figure 225: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Subdiv. 3Ps offshore. The vertical dashed line indicates the minimum legal size.

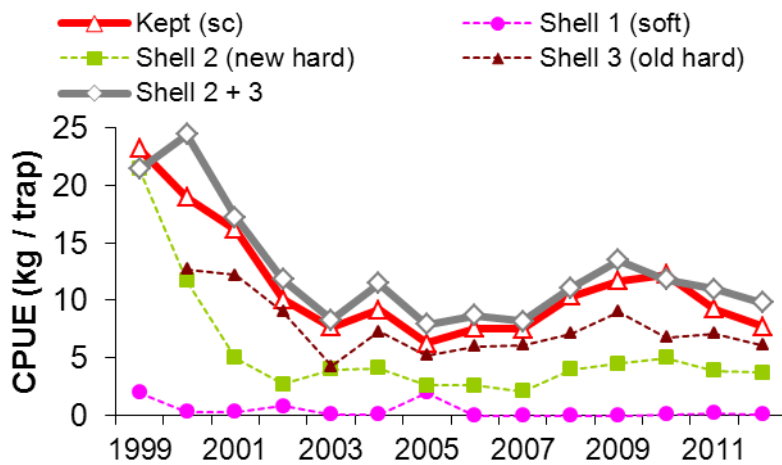


Figure 226: Trends in Subdiv. 3Ps offshore observer catch rates of exploitable crabs by shell condition from at-sea sampling.

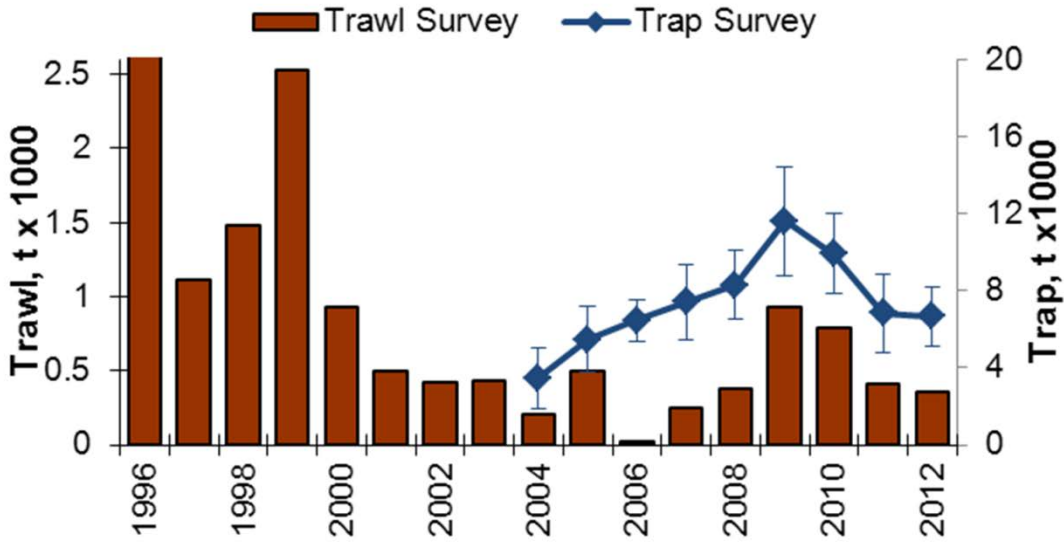


Figure 227: Trends in the Subdiv. 3Ps offshore spring trawl survey exploitable biomass index and the CPS trap survey biomass index. The trawl survey was incomplete in 2006.

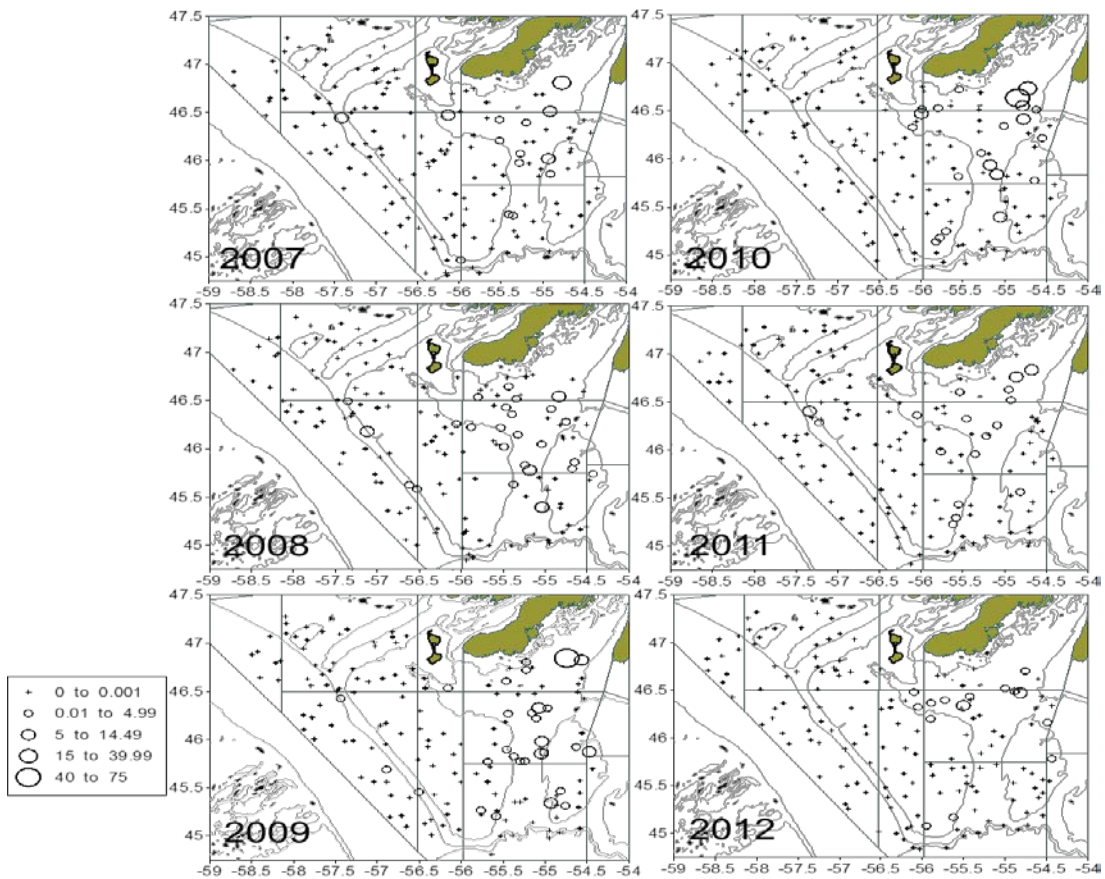


Figure 228: Spatial distribution of catches (number/set) of exploitable crab in the Subdiv. 3Ps offshore trawl survey.

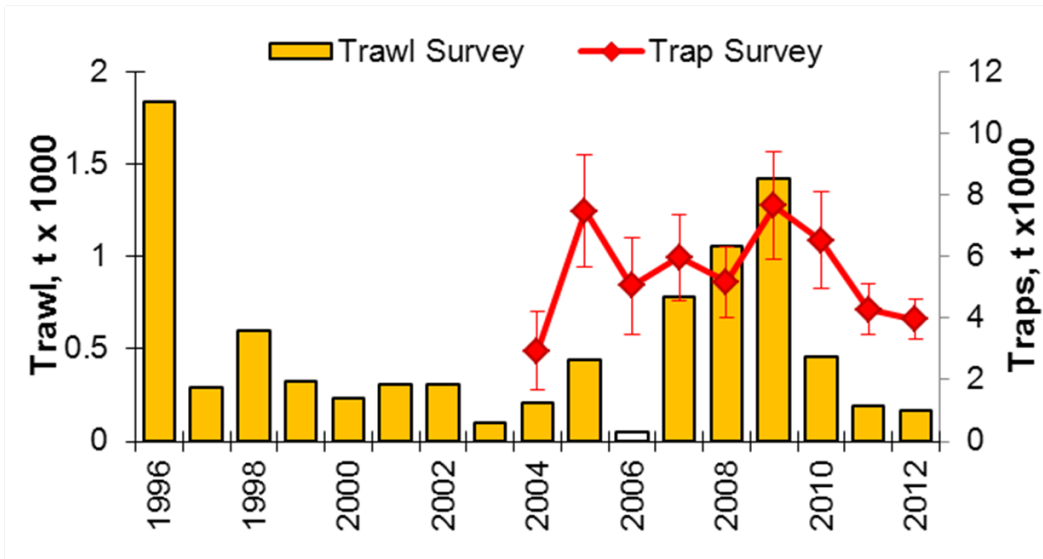


Figure 229: Trends in the Subdiv. 3Ps offshore spring trawl survey pre-recruit biomass index and the CPS trap survey biomass index. The trawl survey was incomplete in 2006.

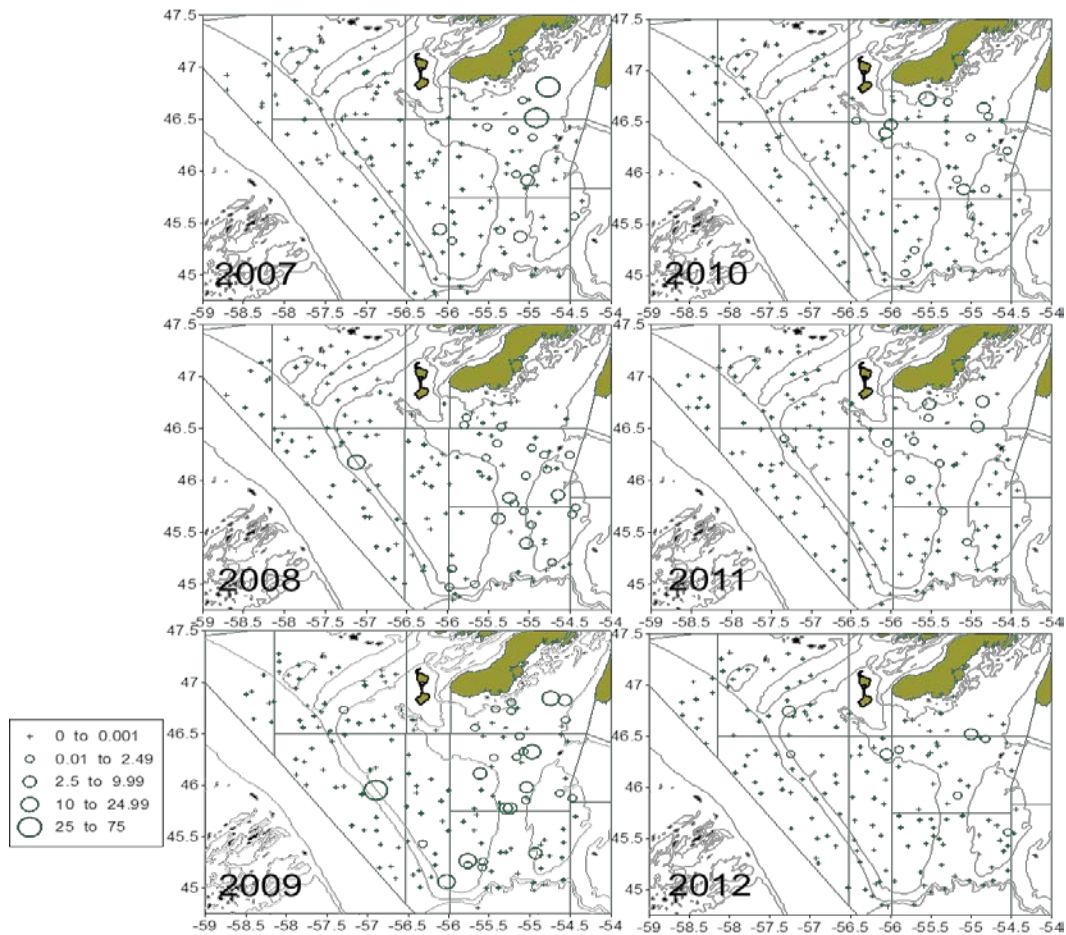


Figure 230: Spatial distribution of catches (number/set) of pre-recruit crab in the Subdiv. 3Ps offshore trawl survey.

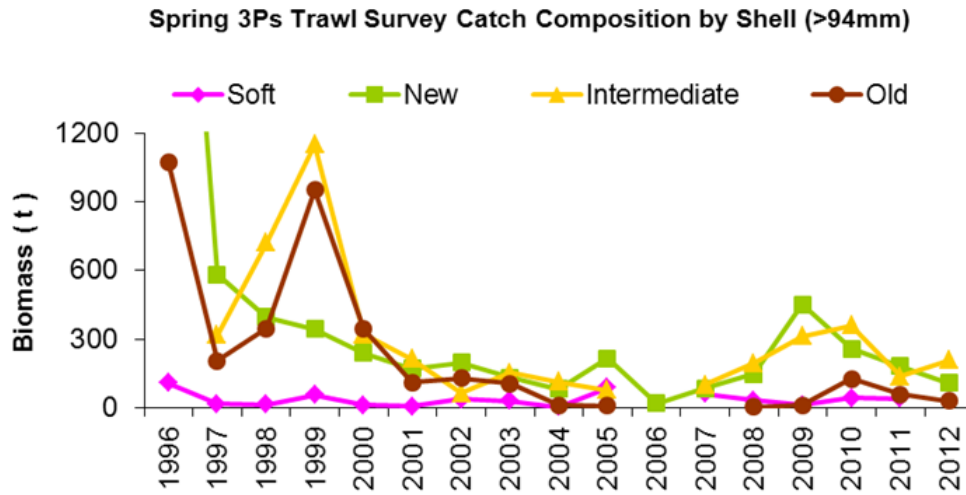


Figure 231: Trends, by shell condition, in legal-sized males for Subdiv. 3Ps offshore from spring trawl surveys.

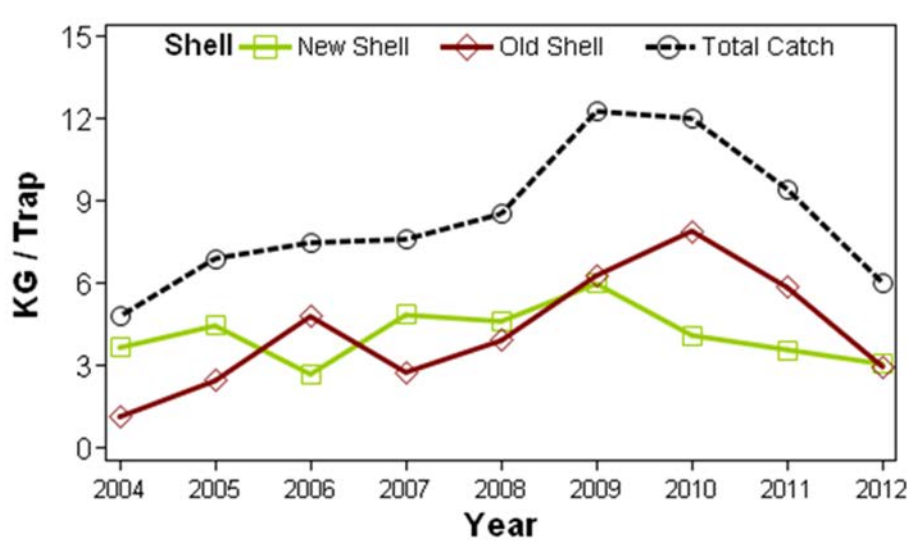


Figure 232: Trends in CPUE by shell condition for legal-sized crabs from core stations in the Subdiv. 3Ps offshore CPS trap survey.

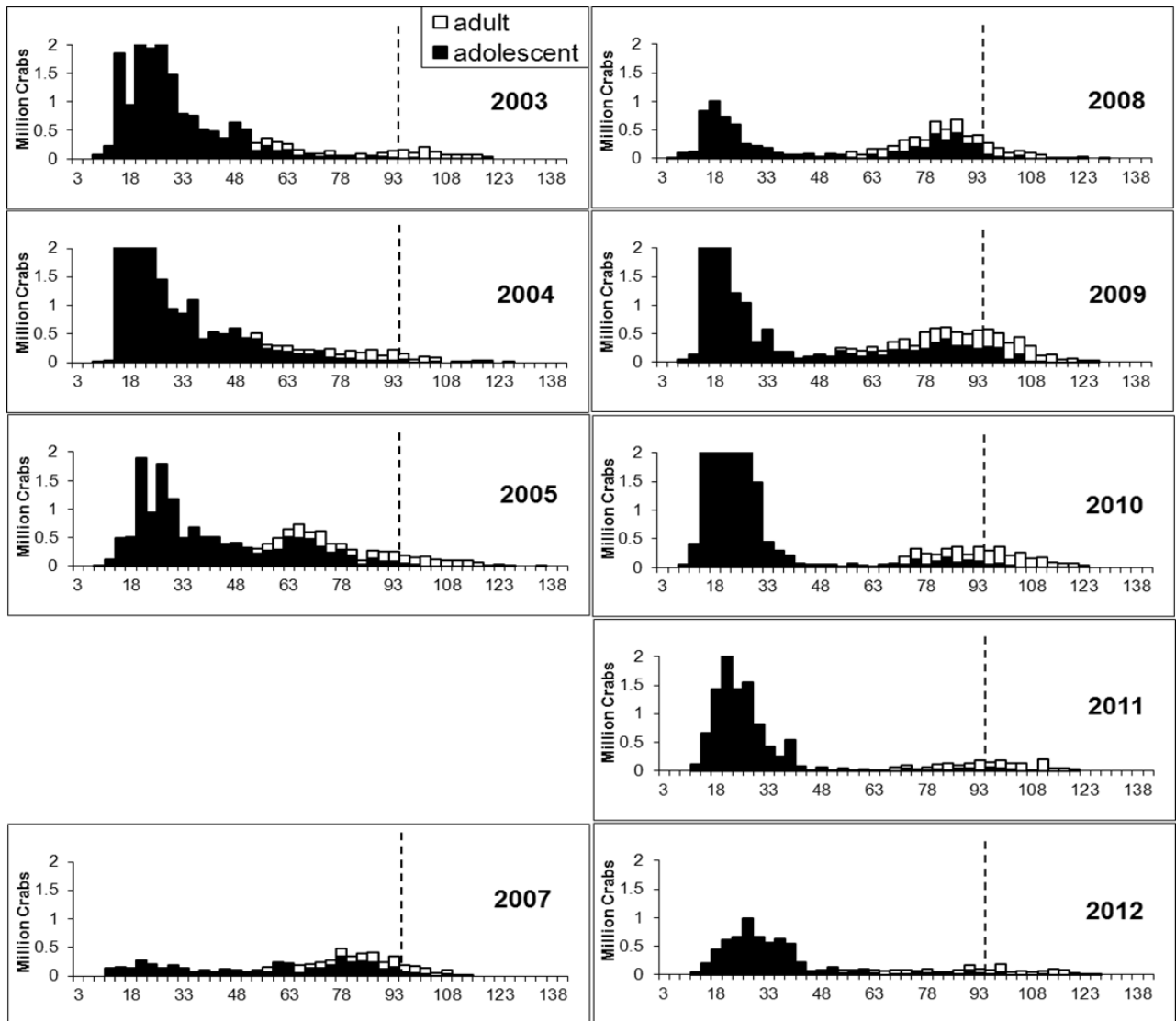


Figure 233: Abundance indices by carapace width for Subdiv. 3Ps juveniles plus adolescents (dark bars) versus adults (open bars) from spring trawl surveys.

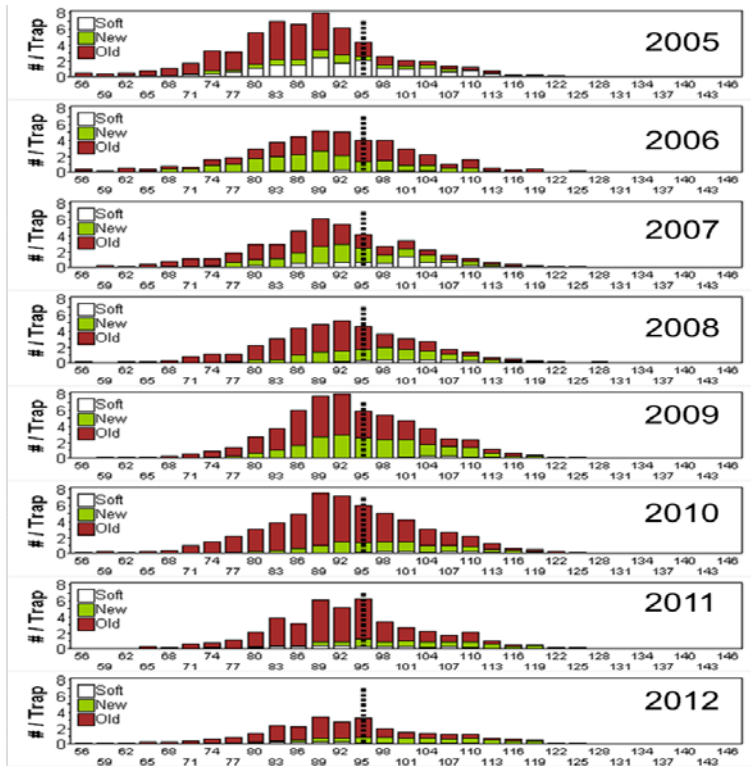


Figure 234: Trends in male carapace width distributions from core stations in the Subdiv. 3Ps offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

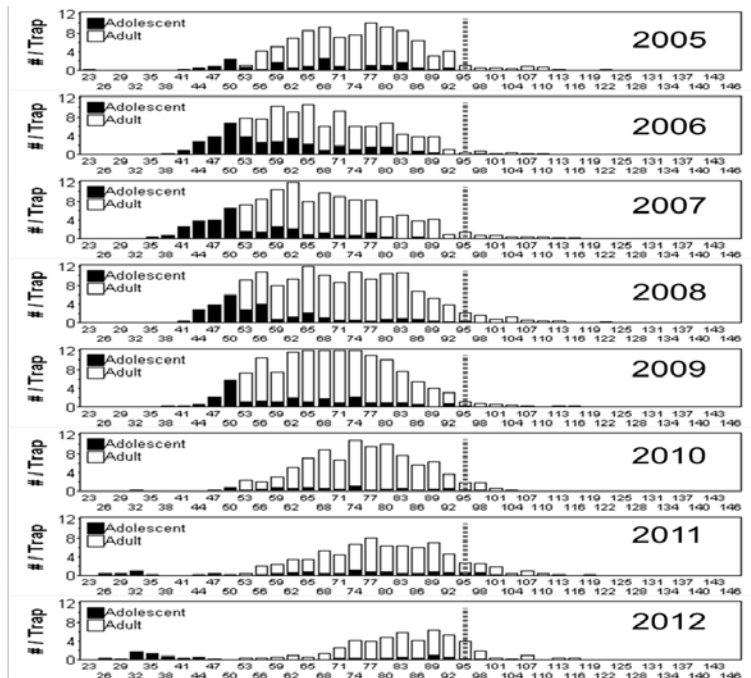


Figure 235: Trends in male carapace width distributions from small-mesh traps in the Subdiv. 3Ps offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

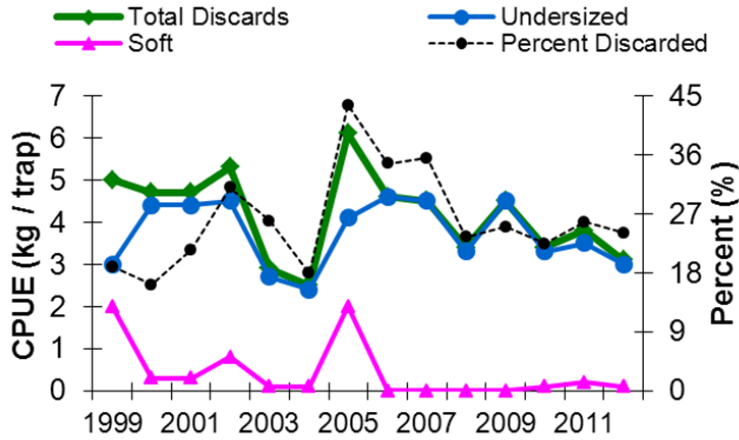


Figure 236: Trends in Subdiv. 3Ps offshore observer catch rates of total discards, under-sized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

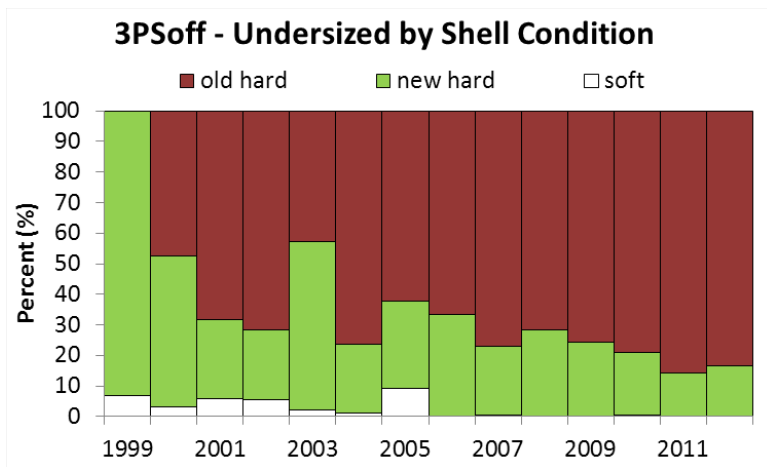


Figure 237: Trends in shell condition of 76-94mm CW crabs from Subdiv. 3Ps offshore observer sampling.

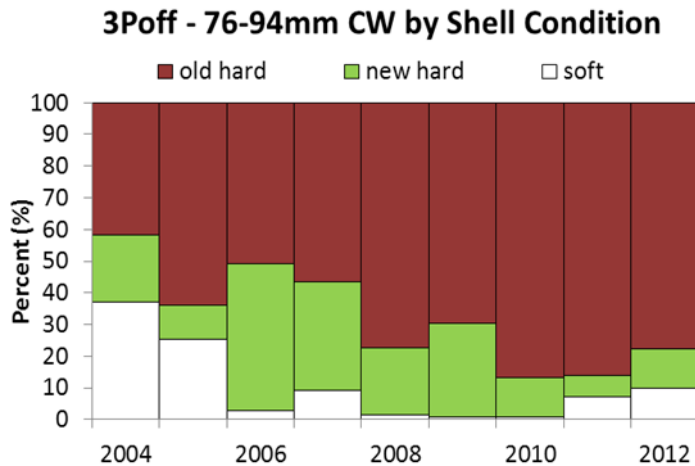


Figure 238: Trends in shell condition of 76-94mm CW crabs from Subdiv. 3Ps offshore CPS trap survey.

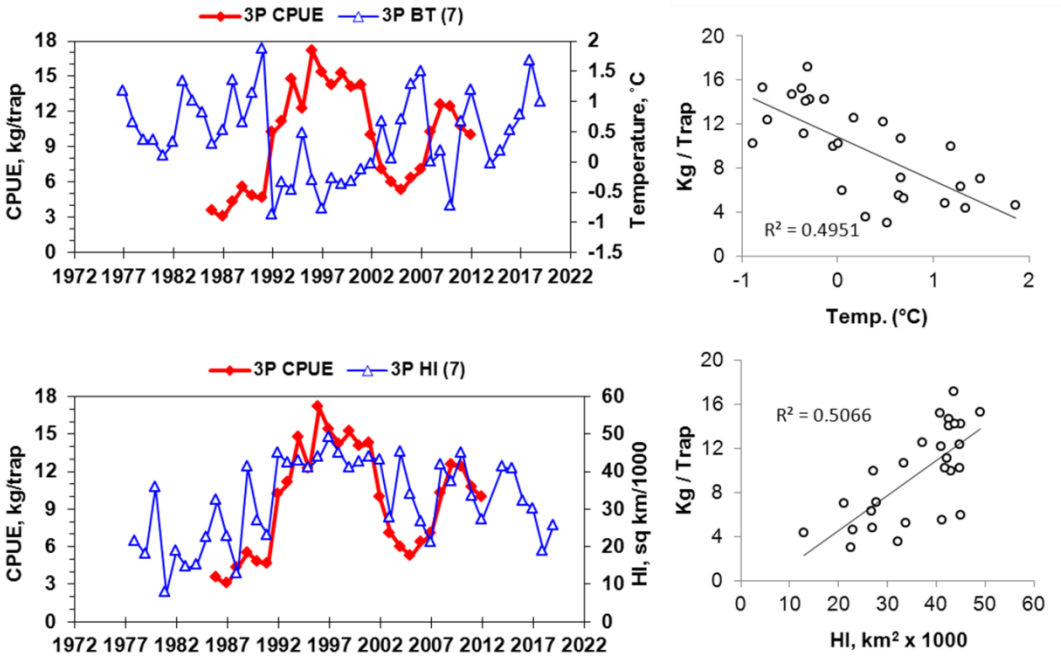


Figure 239: Trends in the Subdiv. 3Ps offshore CPUE vs. bottom temperature (above) and vs. the spatial extent of <1 degree water (below) at a seven year lag (left), and corresponding scatter plots (right).

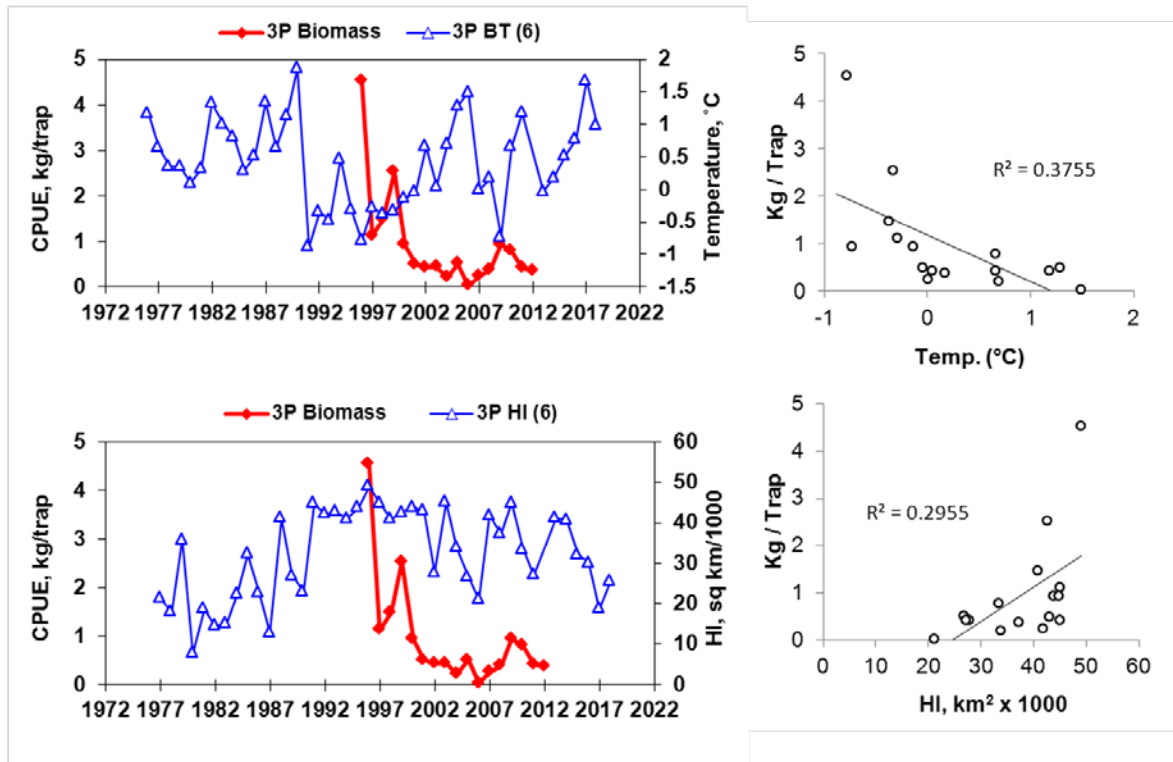


Figure 240: Trends in the Subdiv. 3Ps exploitable biomass index vs. bottom temperature (above) and spatial extent of <1 degree water (below) at a six year lag (left), and corresponding scatter plots (right).

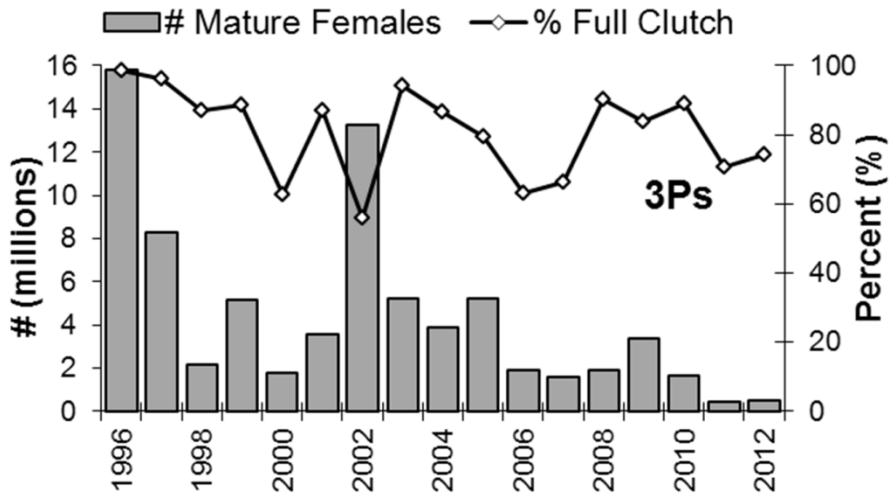


Figure 241: Trends in percent of mature females as well as the percentage of mature females bearing full clutches of viable eggs in Subdiv. 3Ps from spring multi-species surveys.

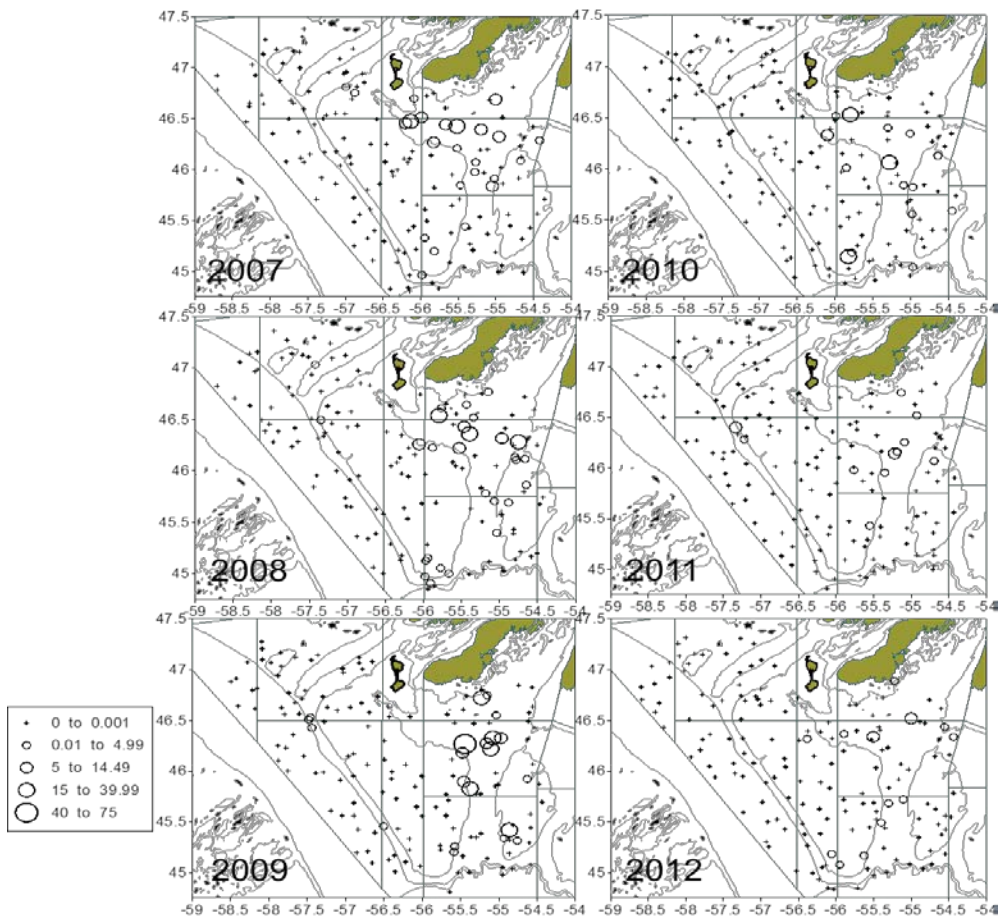


Figure 242: Spatial distribution of catches (number/set) of mature females in the Subdiv. 3Ps offshore trawl survey.

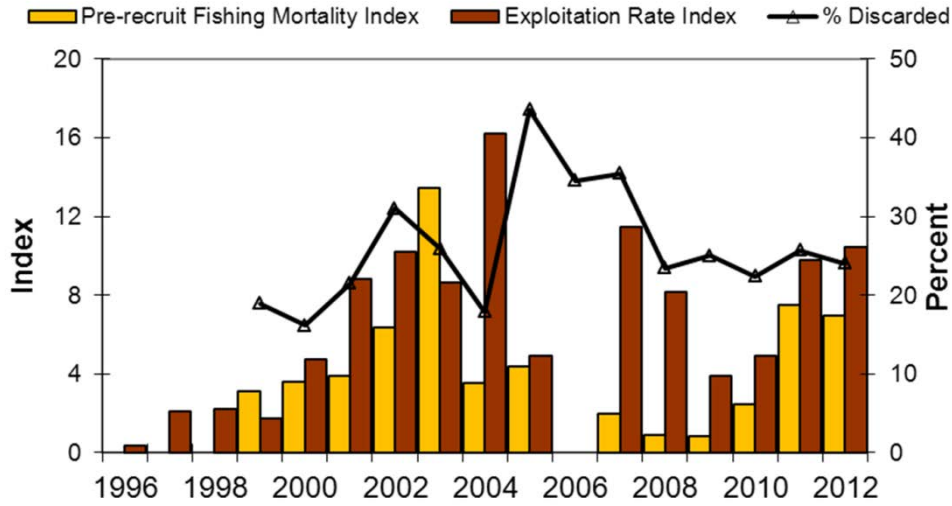


Figure 243: Trends in Subdiv. 3Ps offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery. (No 2006 exploitation rate or pre-recruit fishing mortality indices because of an incomplete 2006 survey).

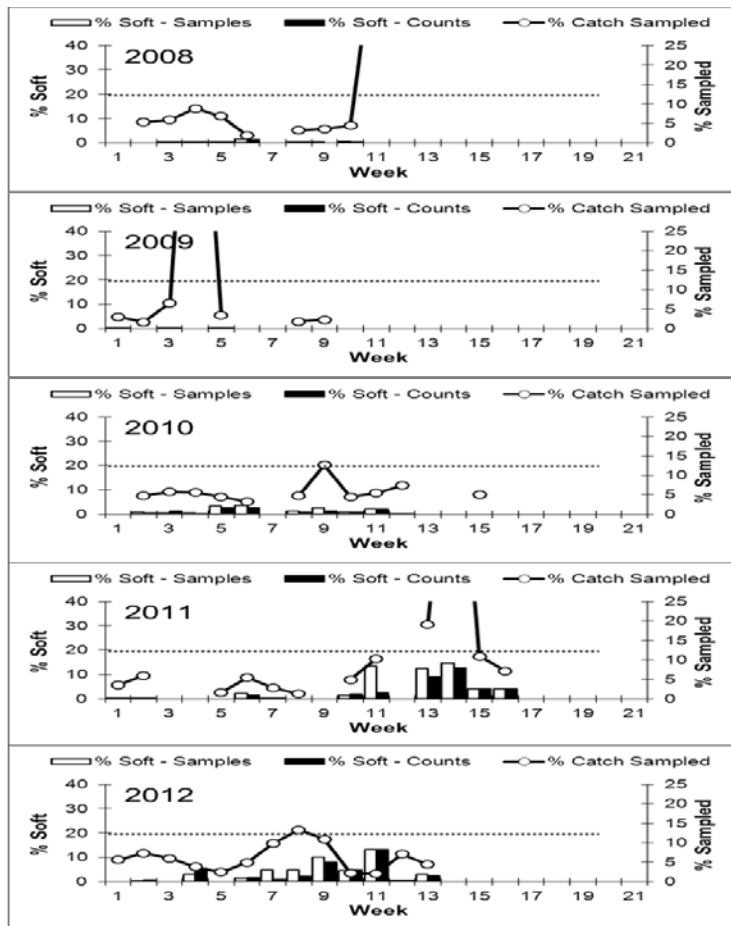


Figure 244: Trends in weekly percentages of soft-shell crab in Subdiv. 3Ps offshore from at-sea sampling by observers.

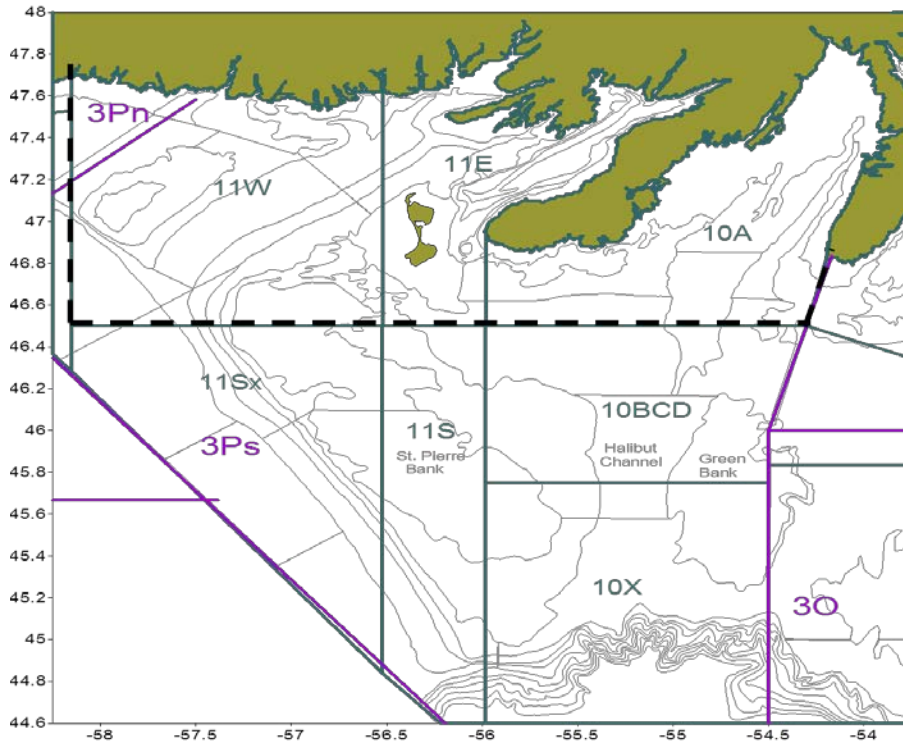


Figure 245: Map of Subdivision 3Ps showing crab management areas and important bathymetric features. Dashed perimeter indicates inshore areas.

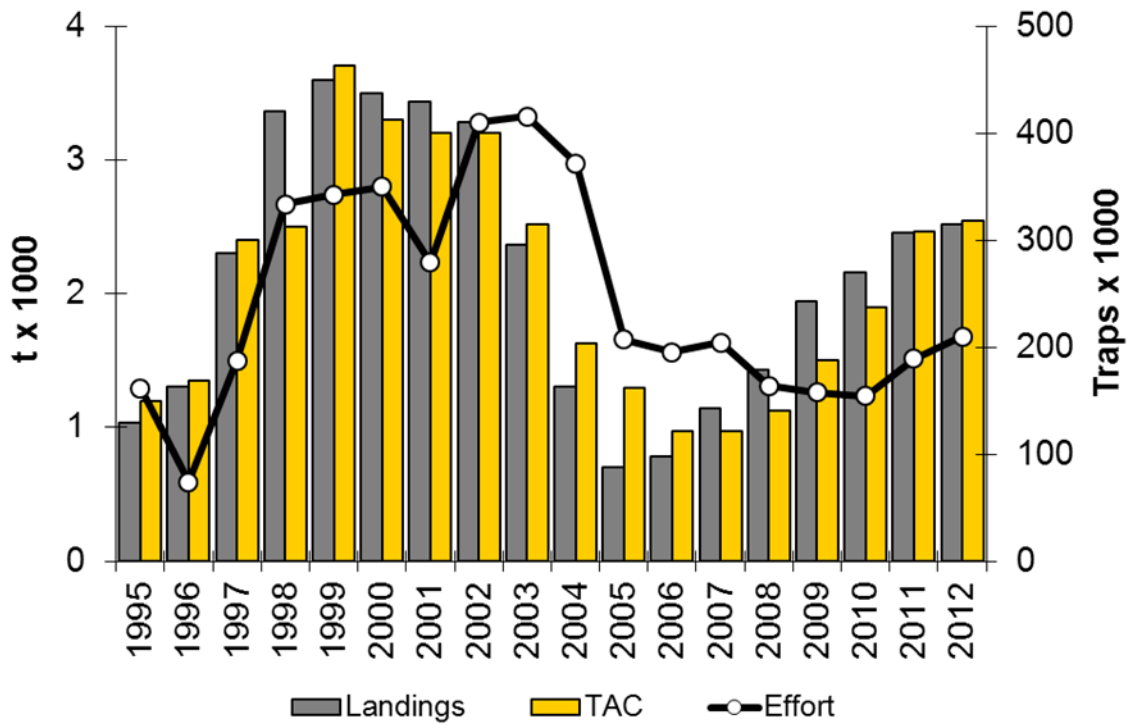


Figure 246: Trends in Subdiv. 3Ps inshore landings, TAC, and fishing effort.

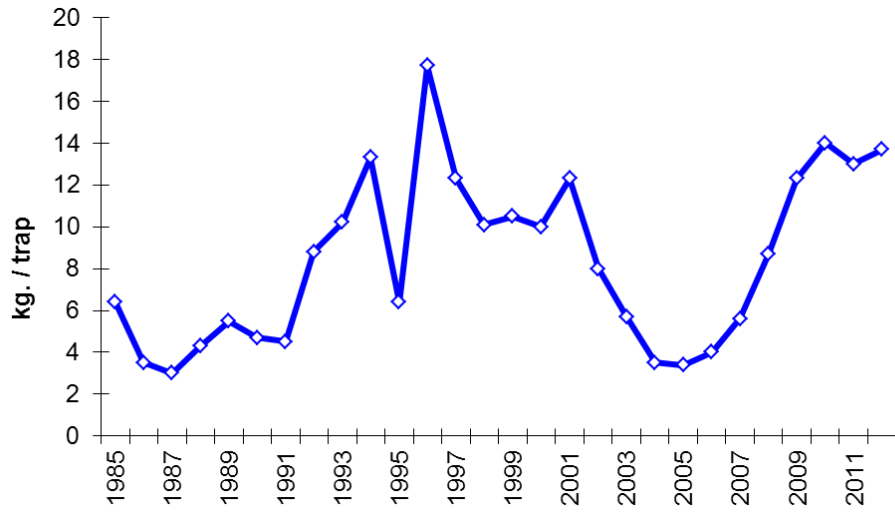


Figure 247: Trends in commercial logbook-based CPUE in the Subdiv. 3Ps inshore fishery.

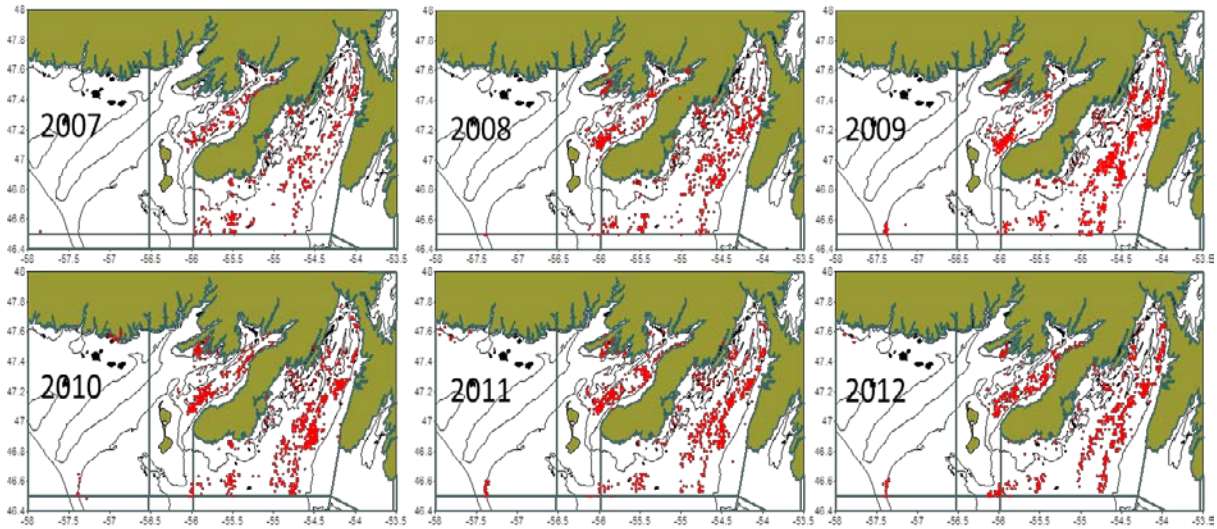


Figure 248: Spatial distribution of Subdiv. 3Ps inshore fishing effort by year

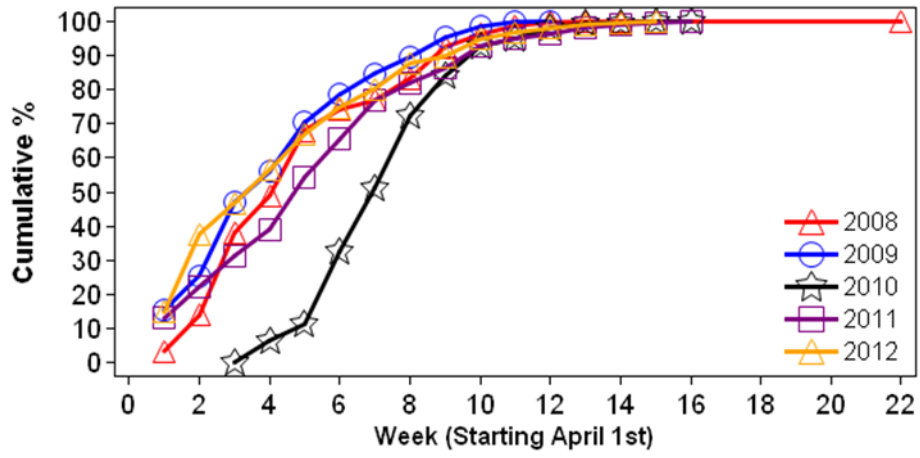


Figure 249: Seasonal trends in weekly fishing effort for Subdiv. 3Ps inshore.

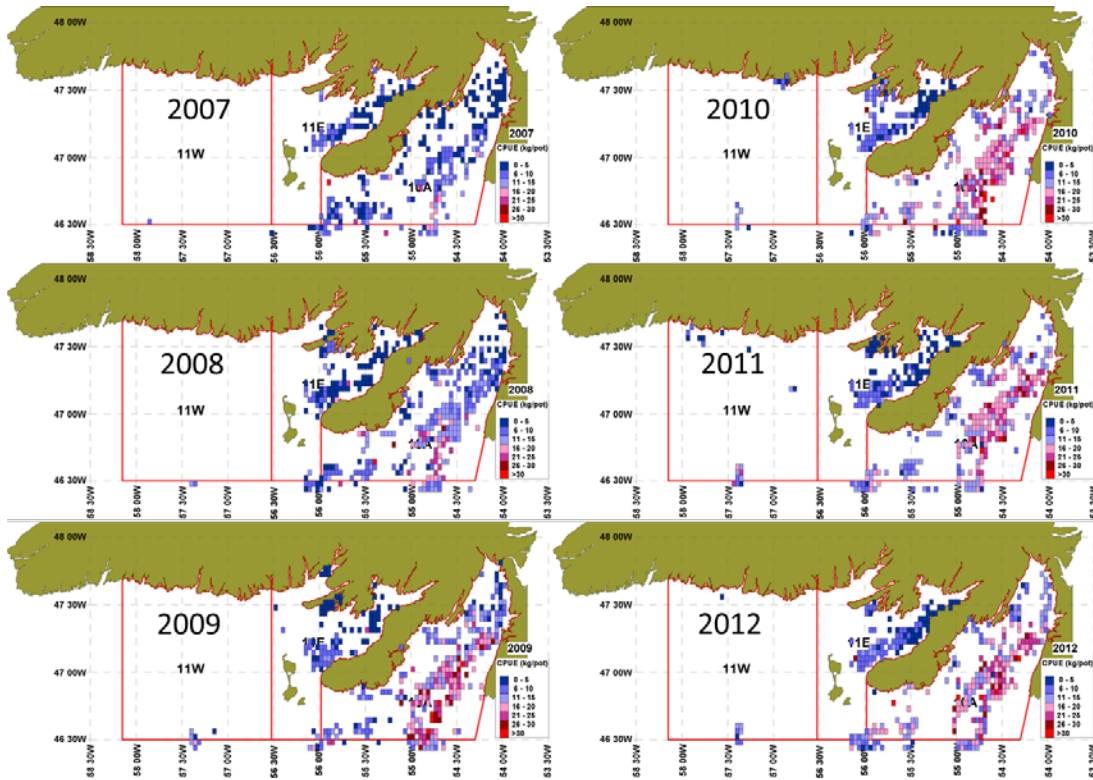


Figure 250: Spatial distribution of Subdiv. 3Ps inshore logbook CPUE by year.

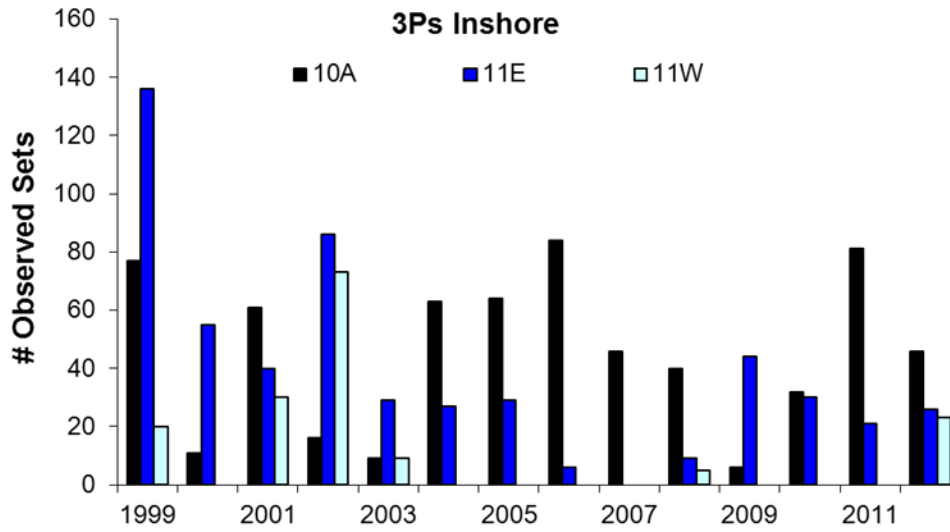


Figure 251: Trends in number of observed sets by Crab Management Areas and year in Subdiv. 3Ps inshore.

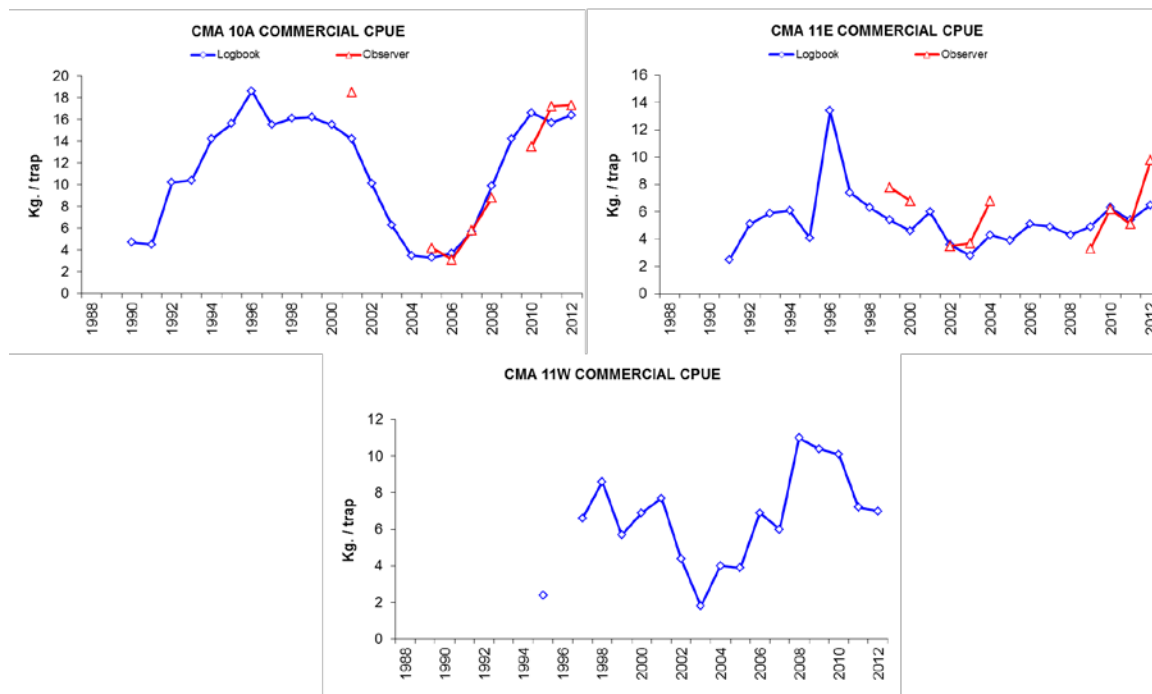


Figure 252: Trends in Subdiv. 3Ps inshore logbook CPUE and observer CPUE by Crab Management Area.

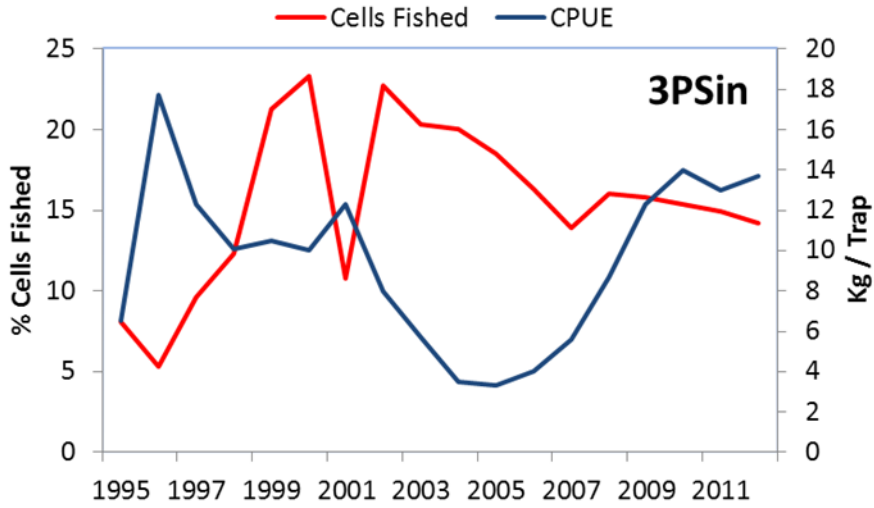


Figure 253: Trends in Subdivision 3Ps inshore logbook CPUE vs. the percentage of 5' x 5' cells fished.

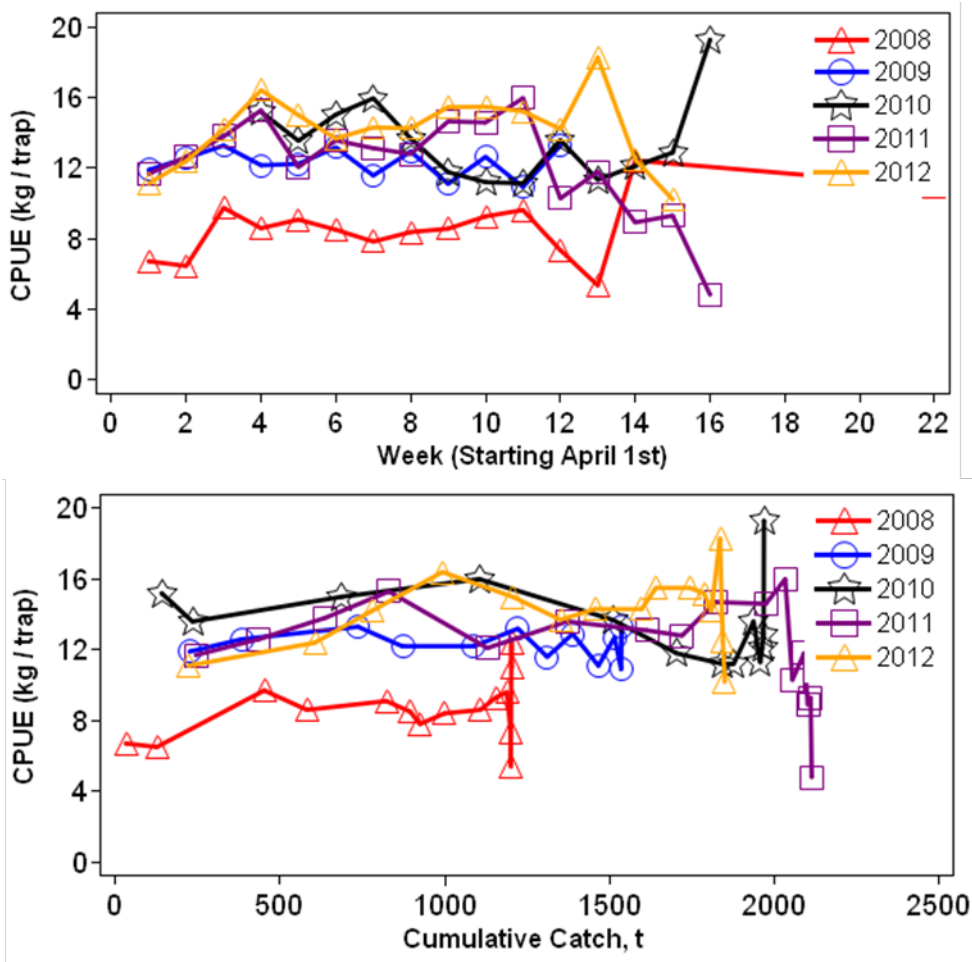


Figure 254: Seasonal trends in logbook-based CPUE for Subdiv. 3Ps inshore; by week (above), and in relation to cumulative catch (below).

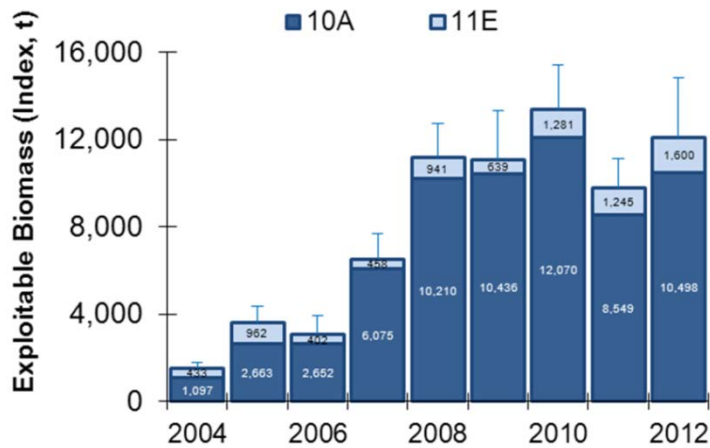


Figure 255: Trends in the exploitable biomass index from the CPS trap survey in Subdivision 3Ps inshore.

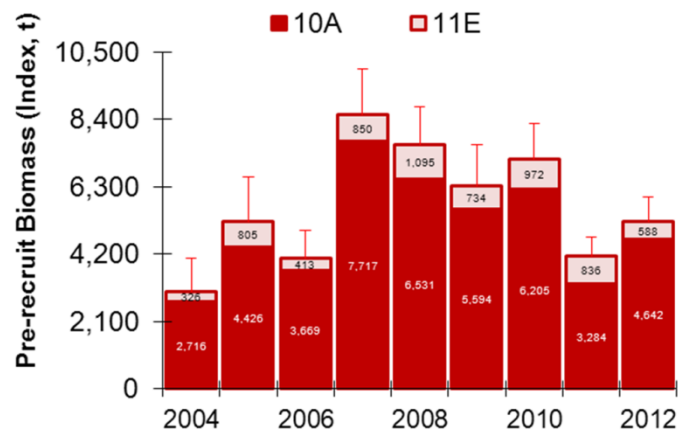


Figure 256: Trends in the pre-recruit biomass index based on the CPS trap survey in Subdiv. 3Ps inshore.

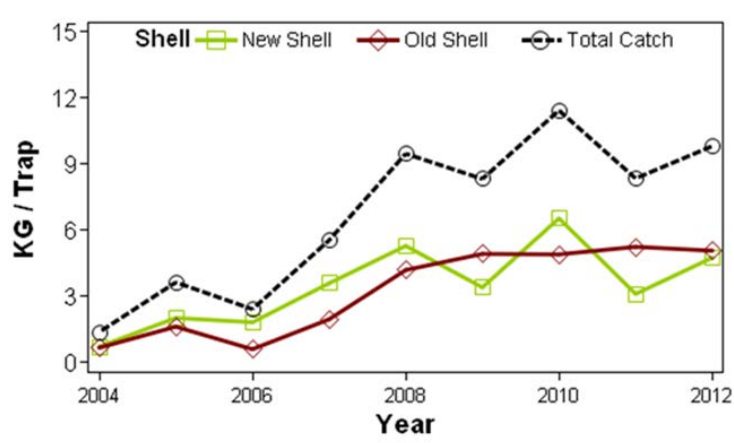


Figure 257: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in Subdiv. 3Ps inshore.

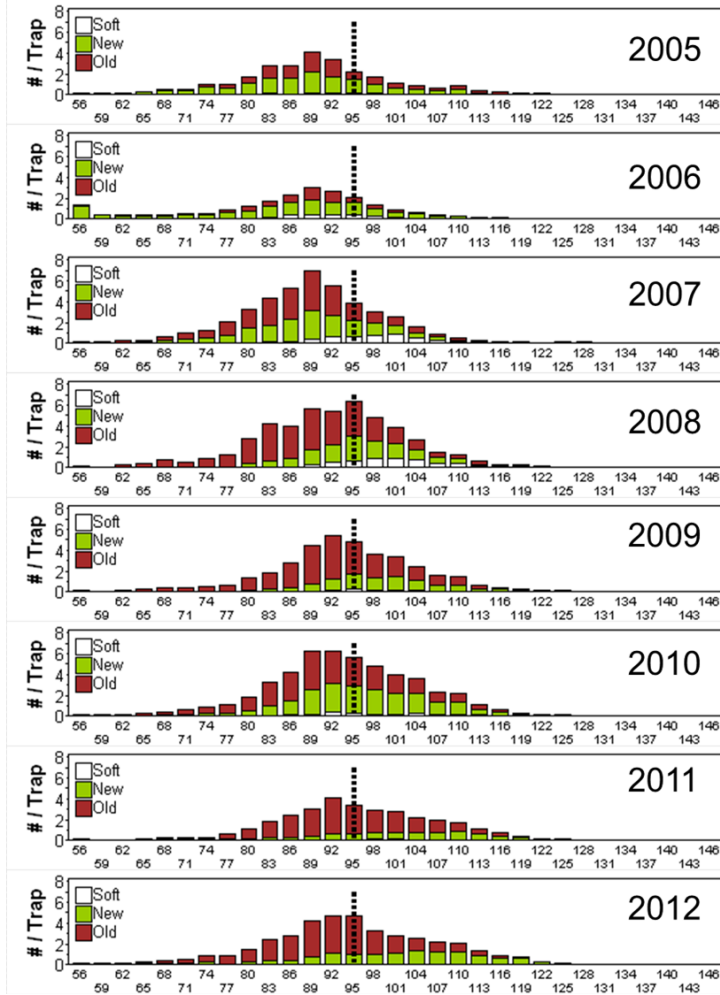


Figure 258: Trends in male carapace width distributions from core stations in the Subdiv. 3Ps inshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

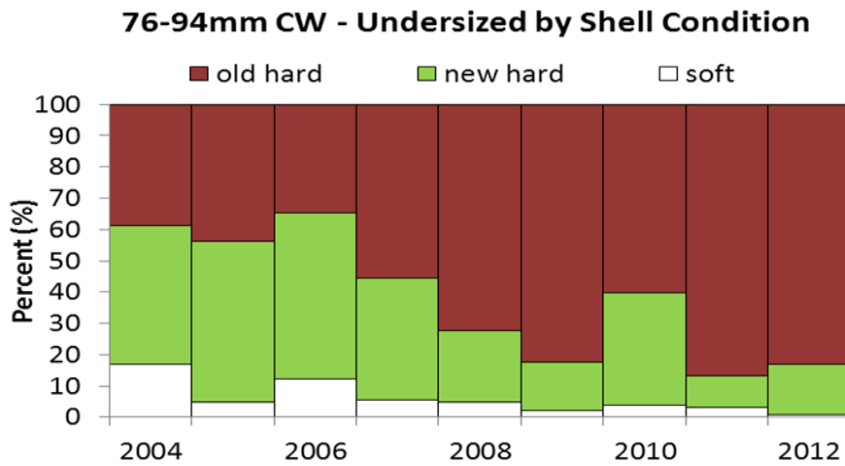


Figure 259: Trends in shell condition of 76-94mm CW crabs from Subdiv. 3Ps inshore CPS trap survey.

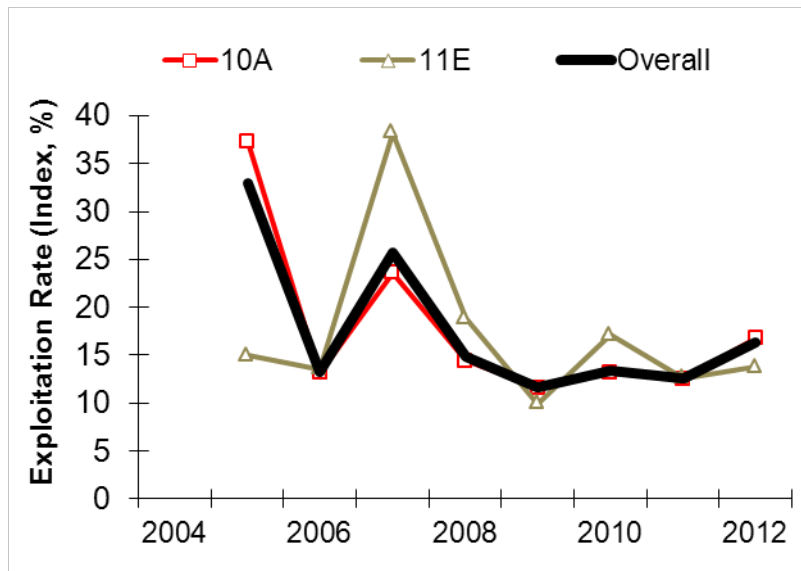


Figure 260: Exploitation rate indices by crab management area as well as overall for Subdiv. 3Ps inshore based on the CPS trap survey.

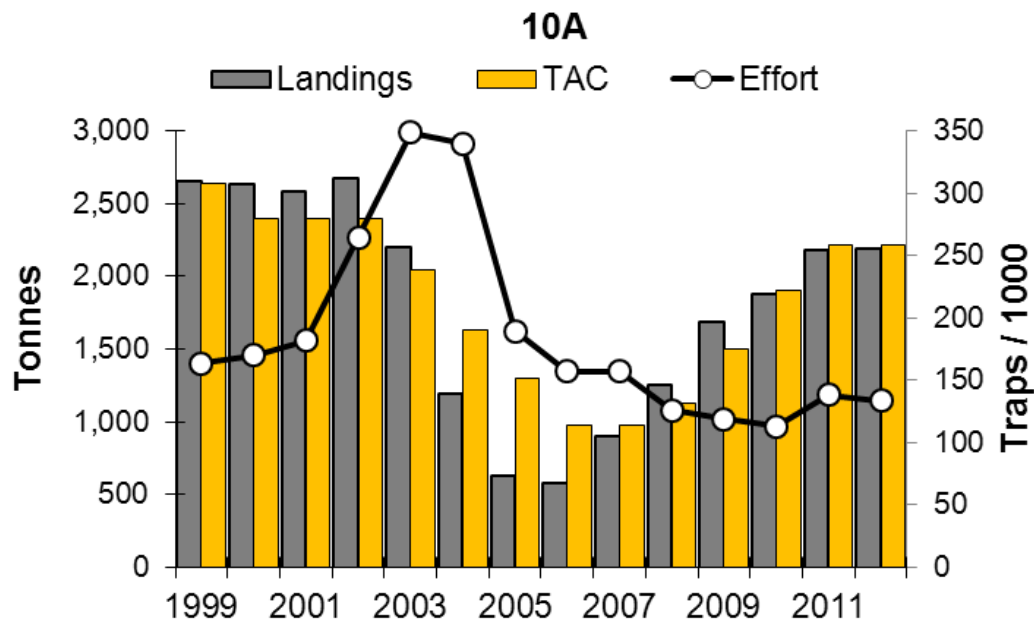


Figure 261: Trends in CMA 10A landings, TAC, and fishing effort.

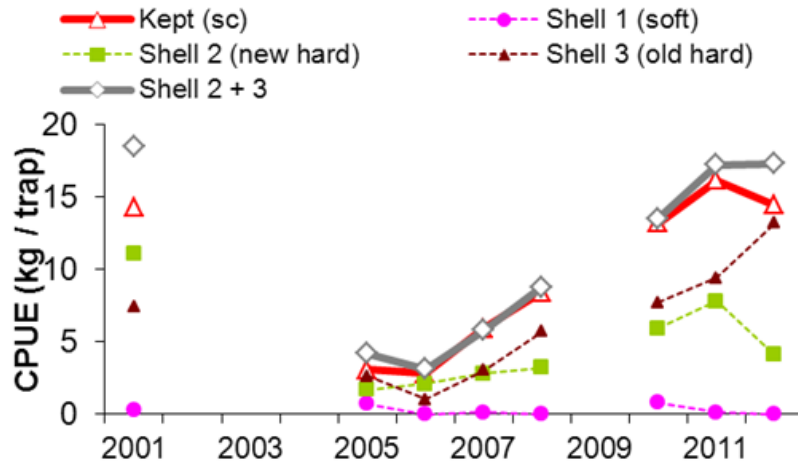


Figure 262: Trends in CMA 10A observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

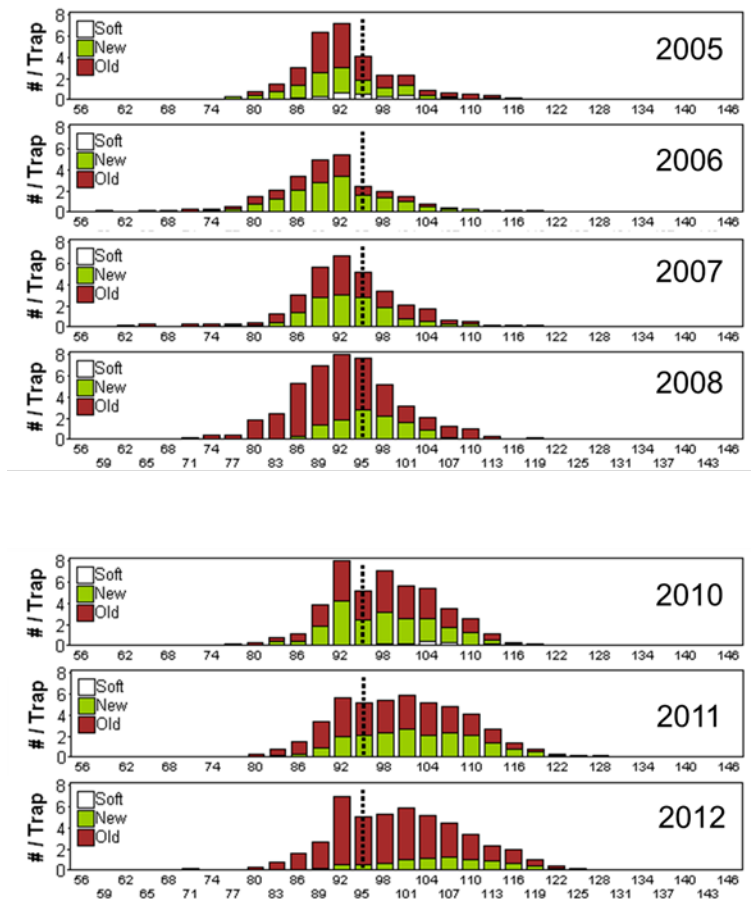


Figure 263: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 10A. The vertical dashed line indicates the minimum legal size.

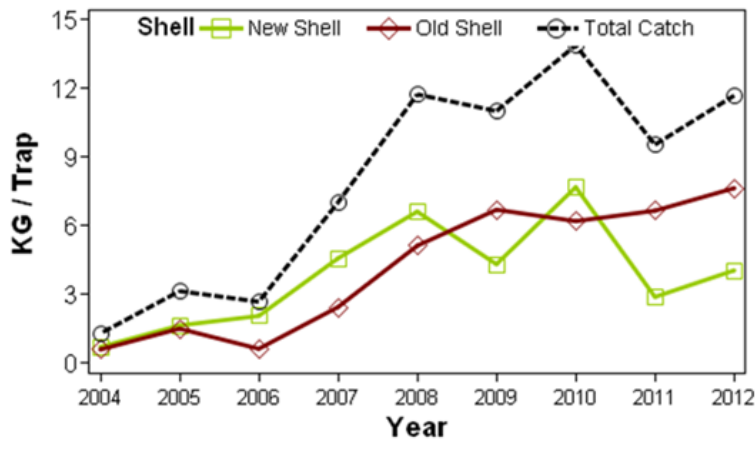


Figure 264: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 10A.

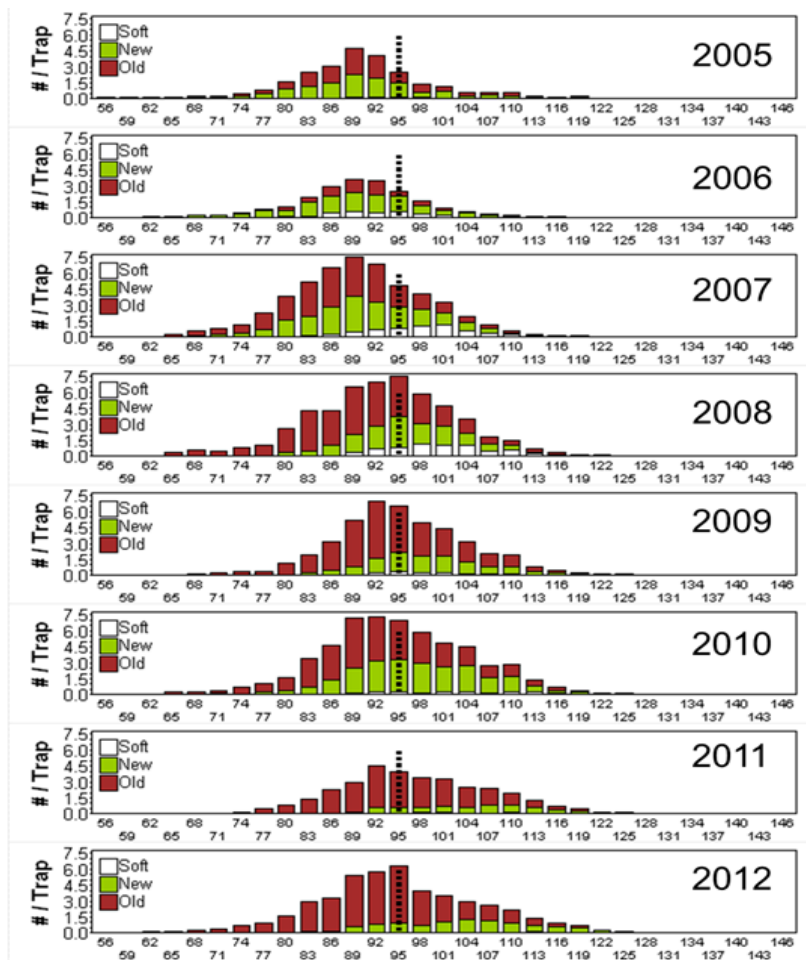


Figure 265: Trends in male carapace width distributions from core stations in the CMA 10A CPS trap survey. The vertical dashed line indicates the minimum legal size.

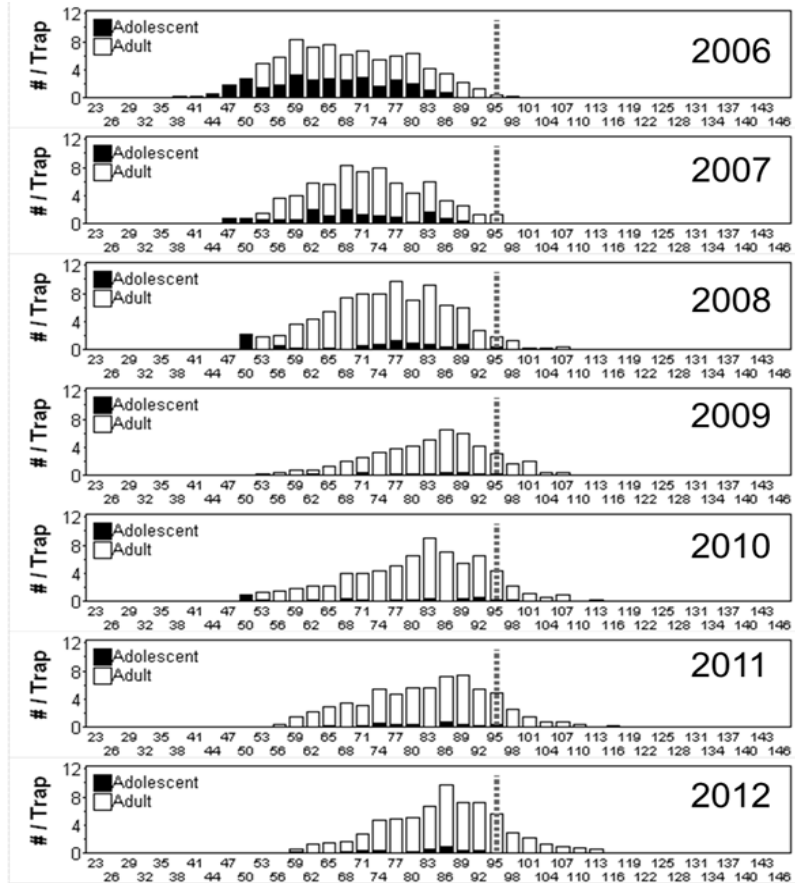


Figure 266: Trends in males carapace width distributions from small-mesh traps in CMA 10A from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

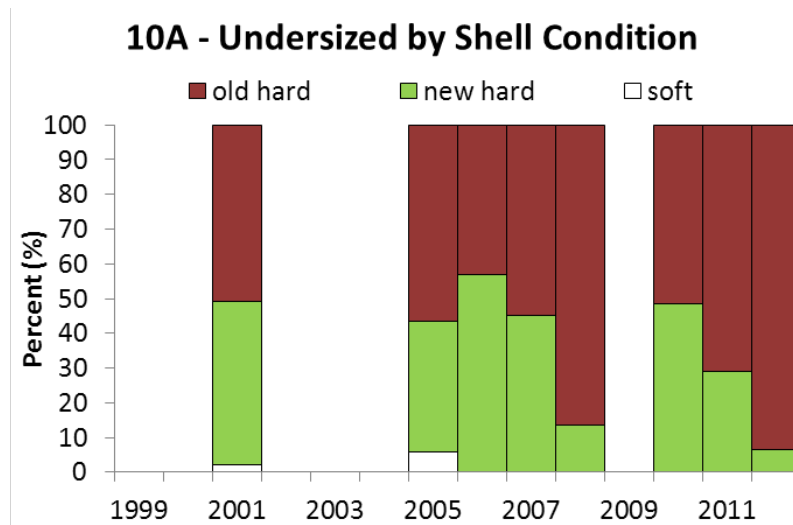


Figure 267: Trends in shell condition of 76-94mm CW crabs from CMA 10A observer sampling.

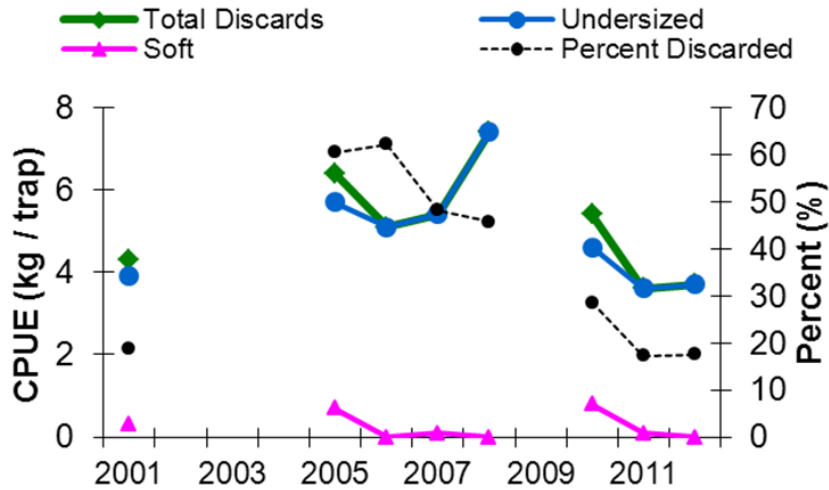


Figure 268: Trends in CMA 10A observer catch rates of total discards, undersized discards, and legalized discards, as well as the percentage of the catch discarded.

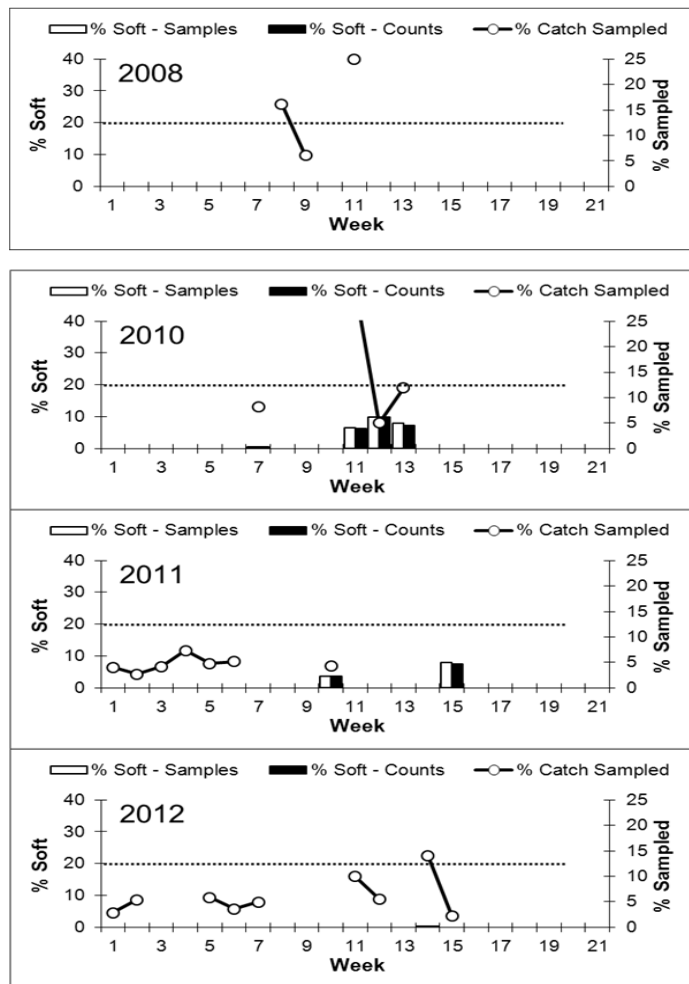


Figure 269: Trends in weekly percentages of soft-shell crab in CMA 10A from at-sea sampling by observers.

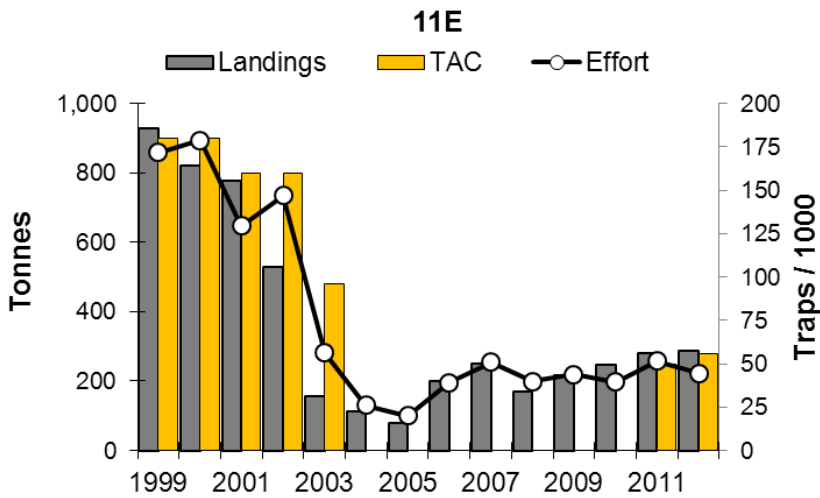


Figure 270: Trends in CMA 11E landings, TAC, and fishing effort.

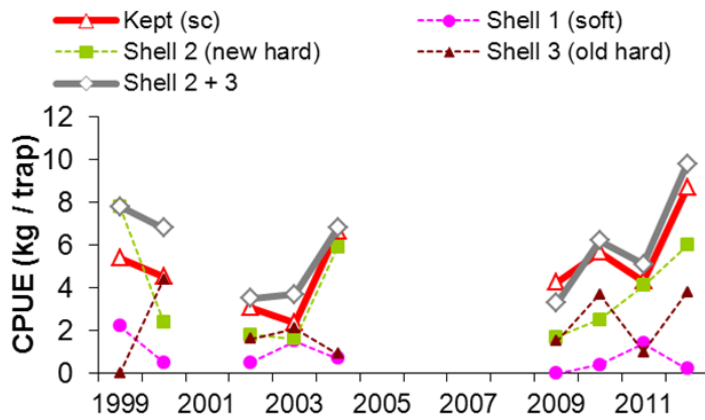


Figure 271: Trends in CMA 11E observer catch rates of exploitable-sized crabs by shell condition category from at-sea sampling.

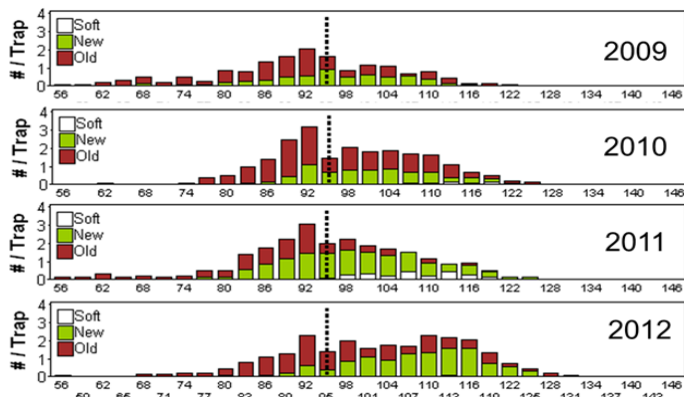


Figure 272: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 11E. The vertical dashed line indicates the minimum legal size

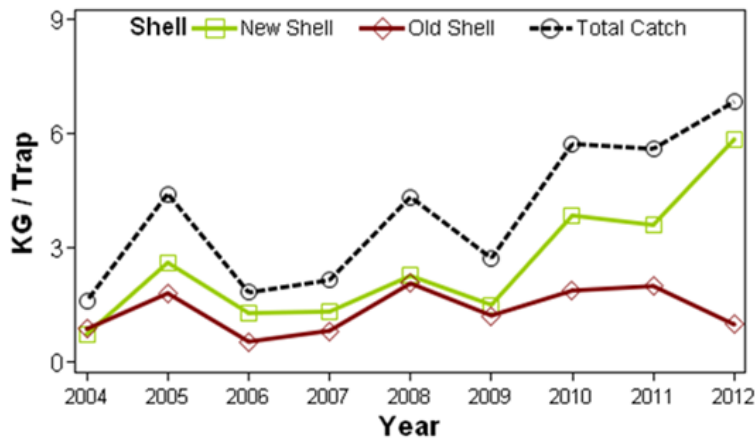


Figure 273: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 11E.

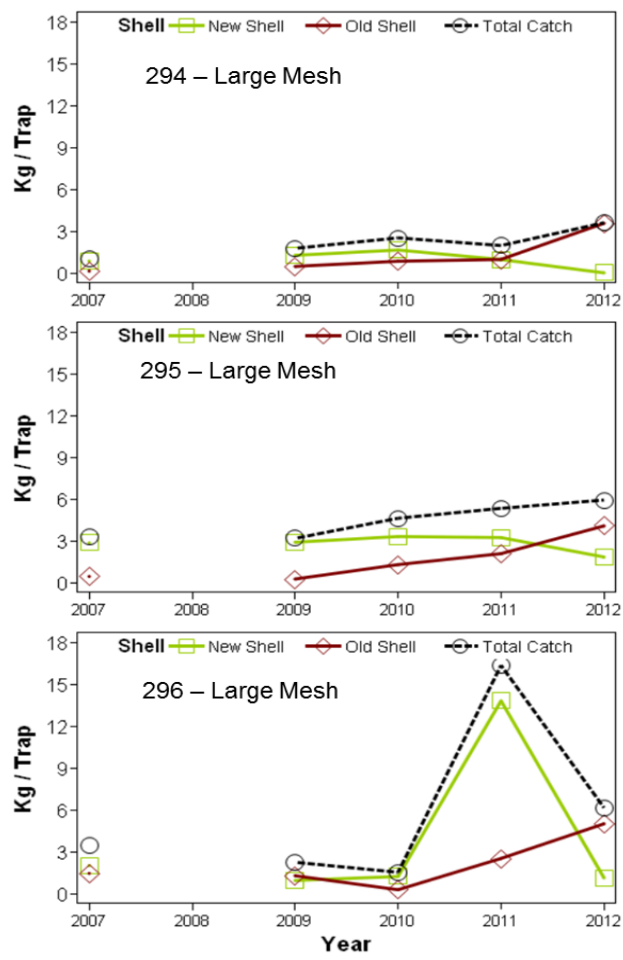


Figure 274: Trends in CPUE by shell condition for legal-sized crabs from strata occupied in the DFO trap survey in Fortune Bay.

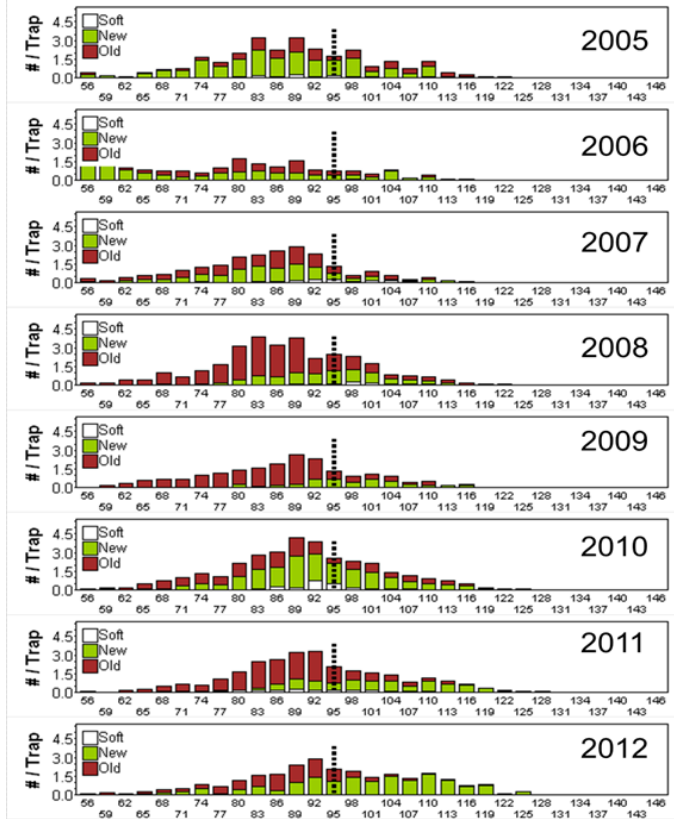


Figure 275: Trends in male carapace width distributions from core stations in the CMA 11E CPS trap survey. The vertical dashed line indicates the minimum legal size.

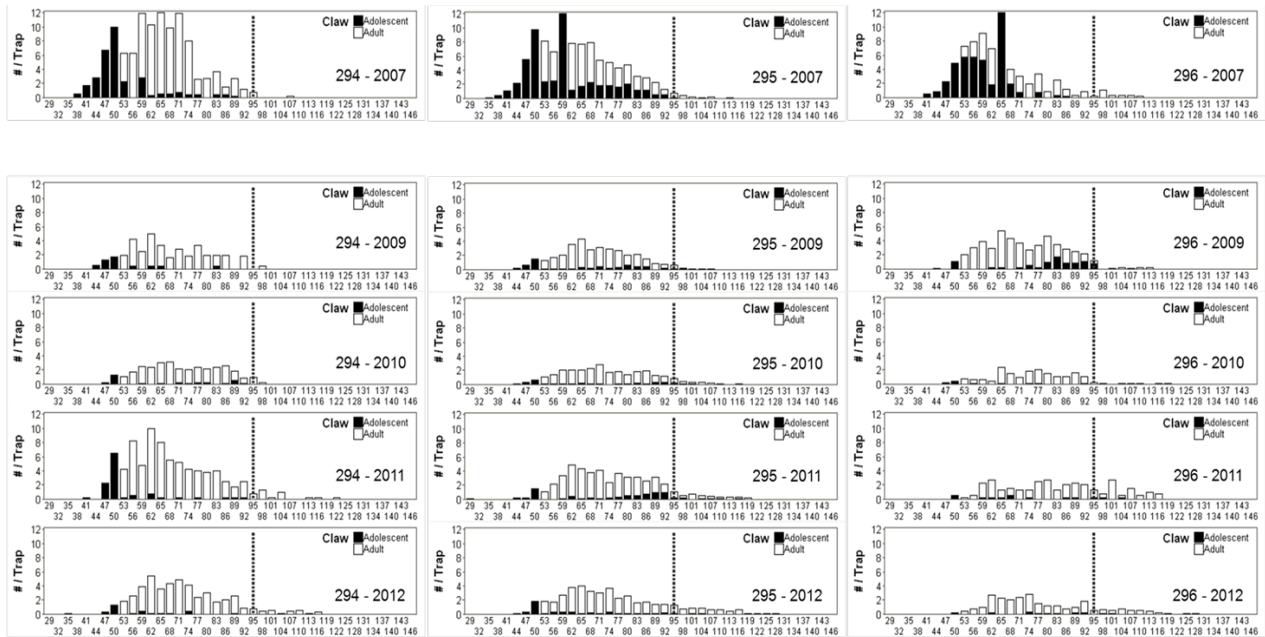


Figure 276: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in DFO trap survey in Fortune Bay. The vertical dashed line indicates the minimum legal size.

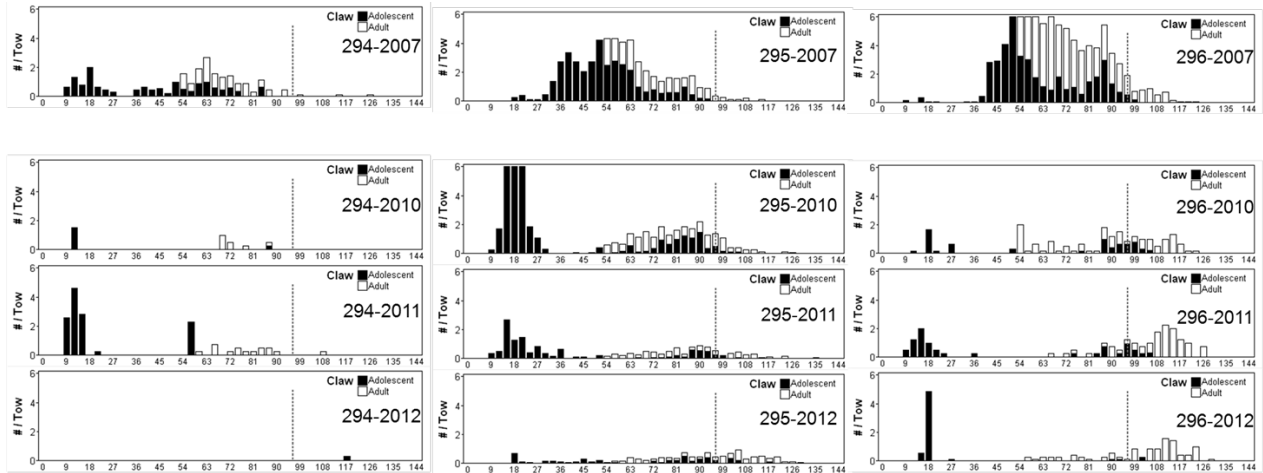


Figure 277: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from the DFO trawl survey in Fortune Bay. The vertical dashed line indicates the minimum legal size.

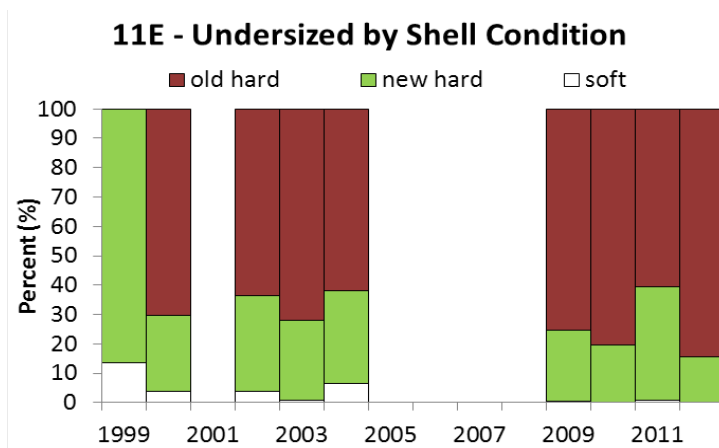


Figure 278: Trends in shell condition of 76-94mm CW crabs from CMA 11E observer sampling.

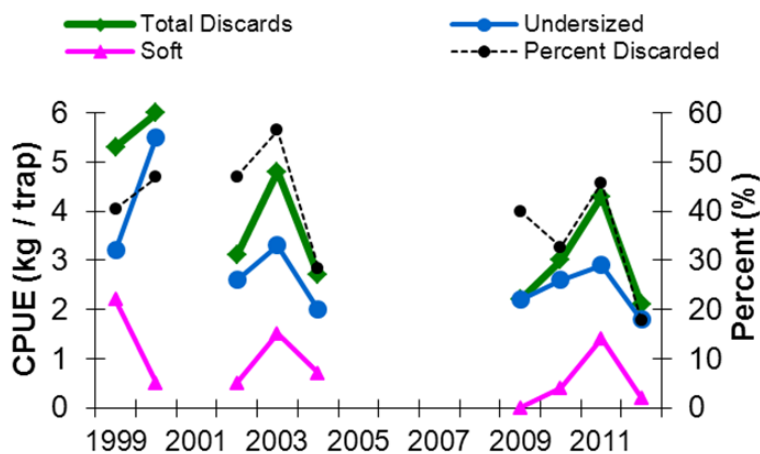


Figure 279: Trends in CMA 11E observer catch rates of total discards, undersized discards, and legal-sized discards, as well as the percentage of the catch discarded.

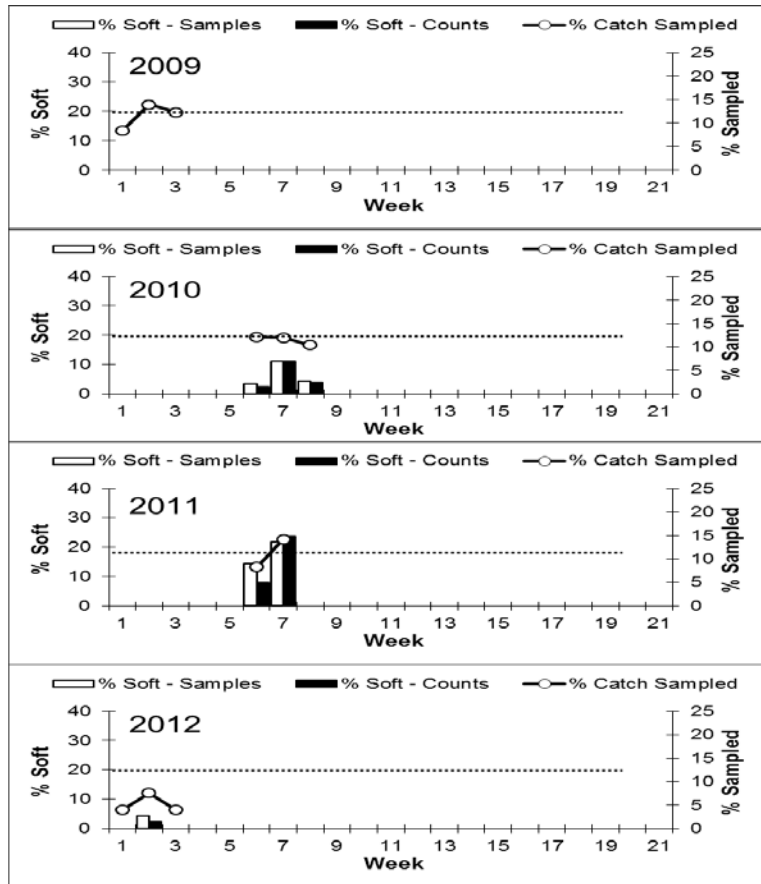


Figure 280: Trends in weekly percentages of soft-shell crab in CMA 11E from at-sea sampling by observers.

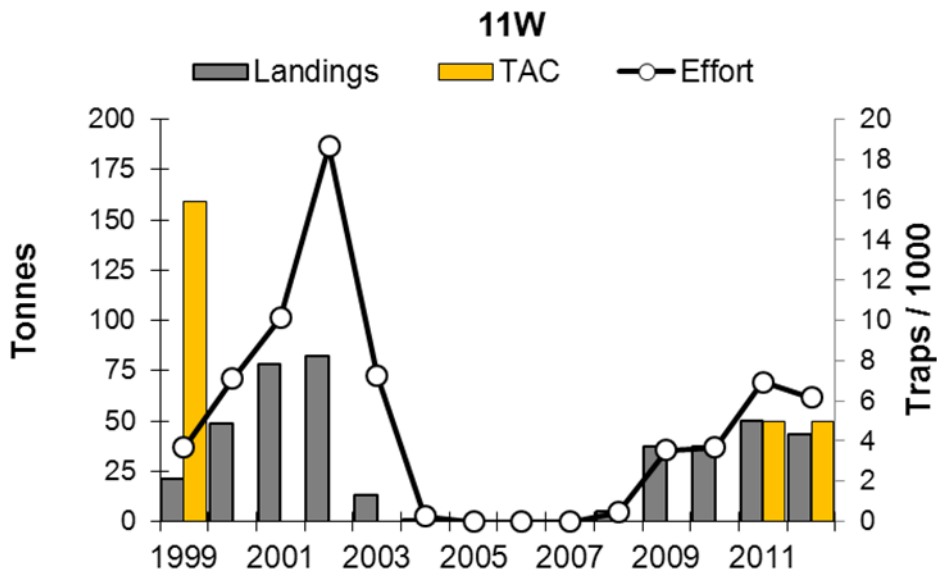


Figure 281: Trends in CMA 11W landings, TAC, and fishing effort.

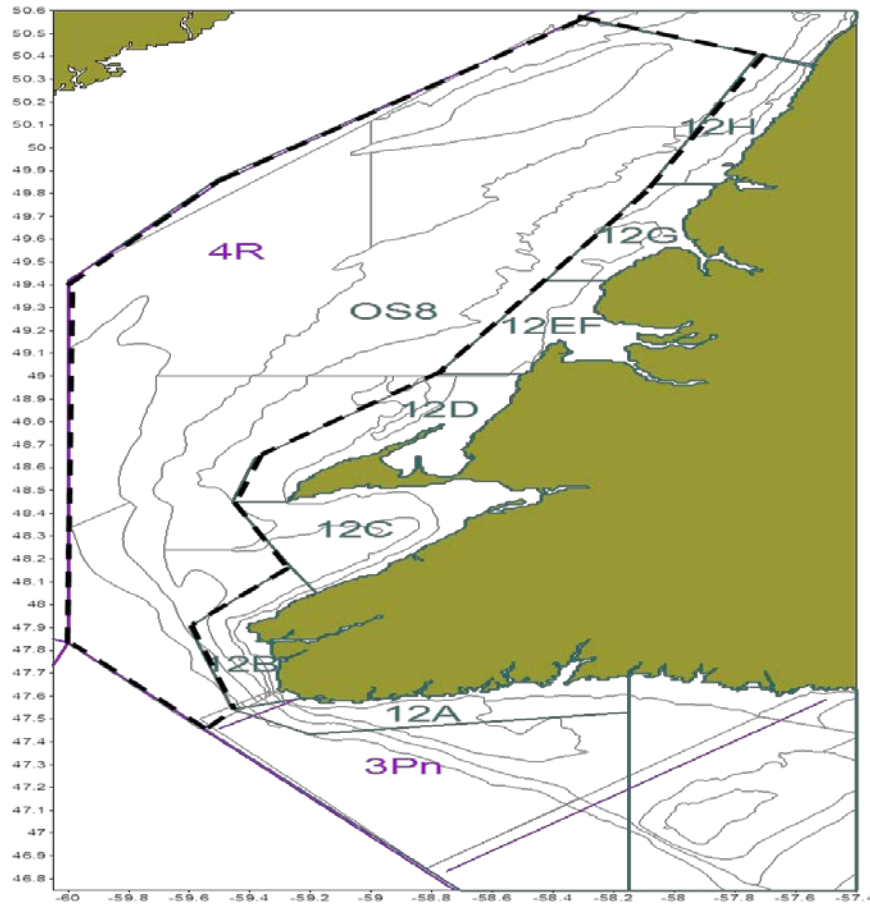


Figure 282: Map of Division 4R showing crab management areas and important bathymetric features. Dashed perimeter indicates offshore areas.

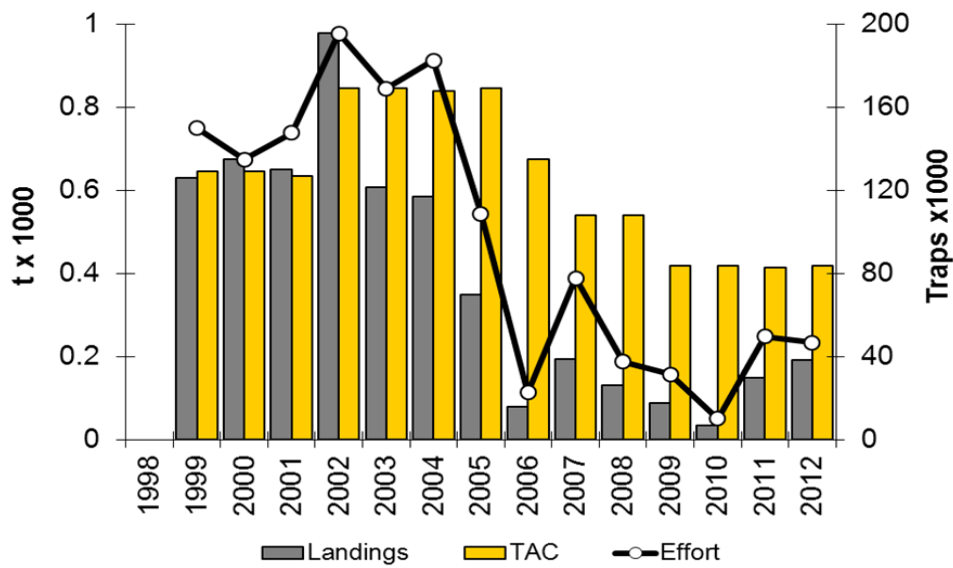


Figure 283: Trends in Div. 4R offshore landings, TAC, and fishing effort.

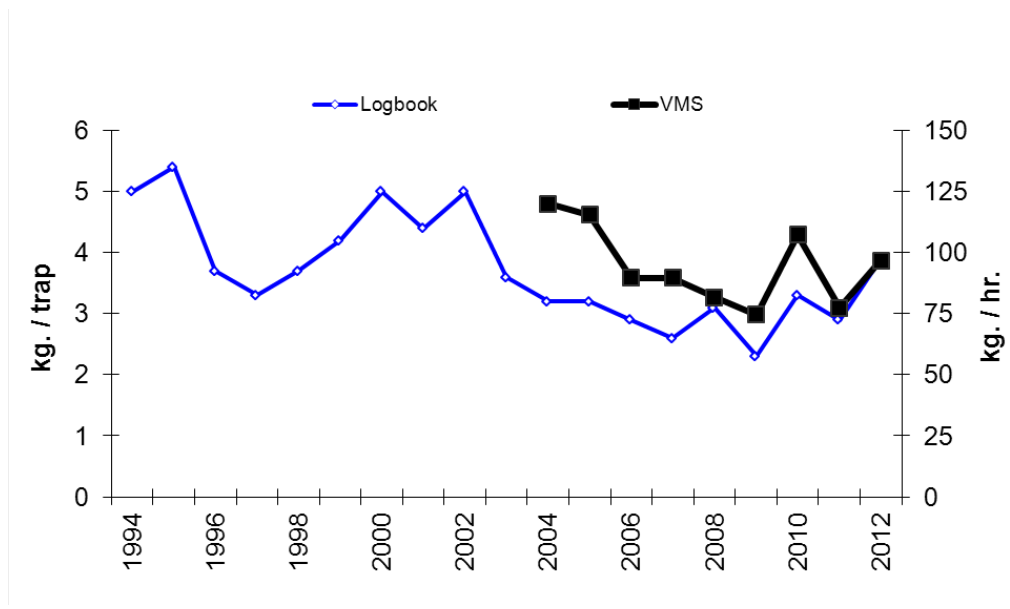


Figure 284: Trends in commercial logbook-based and VMS-based CPUE in the Division 4R offshore fishery.

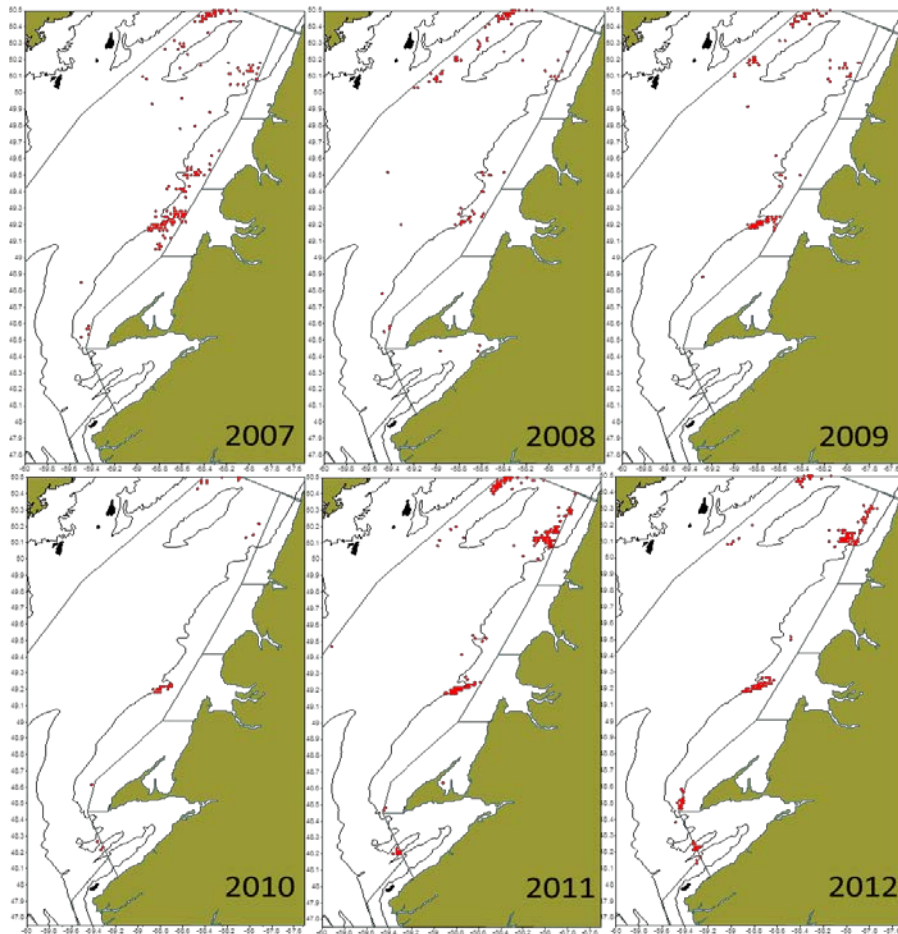


Figure 285: Spatial distribution of Div. 4R offshore fishing effort by year.

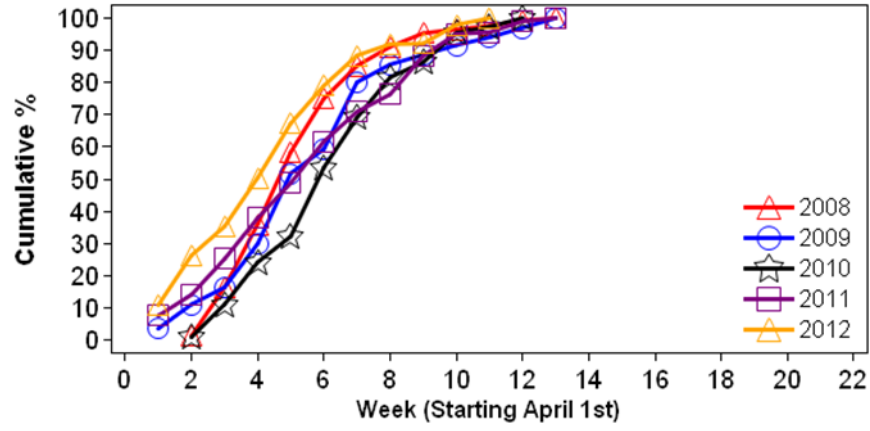


Figure 286: Seasonal trends in weekly fishing effort for Div. 4R offshore.

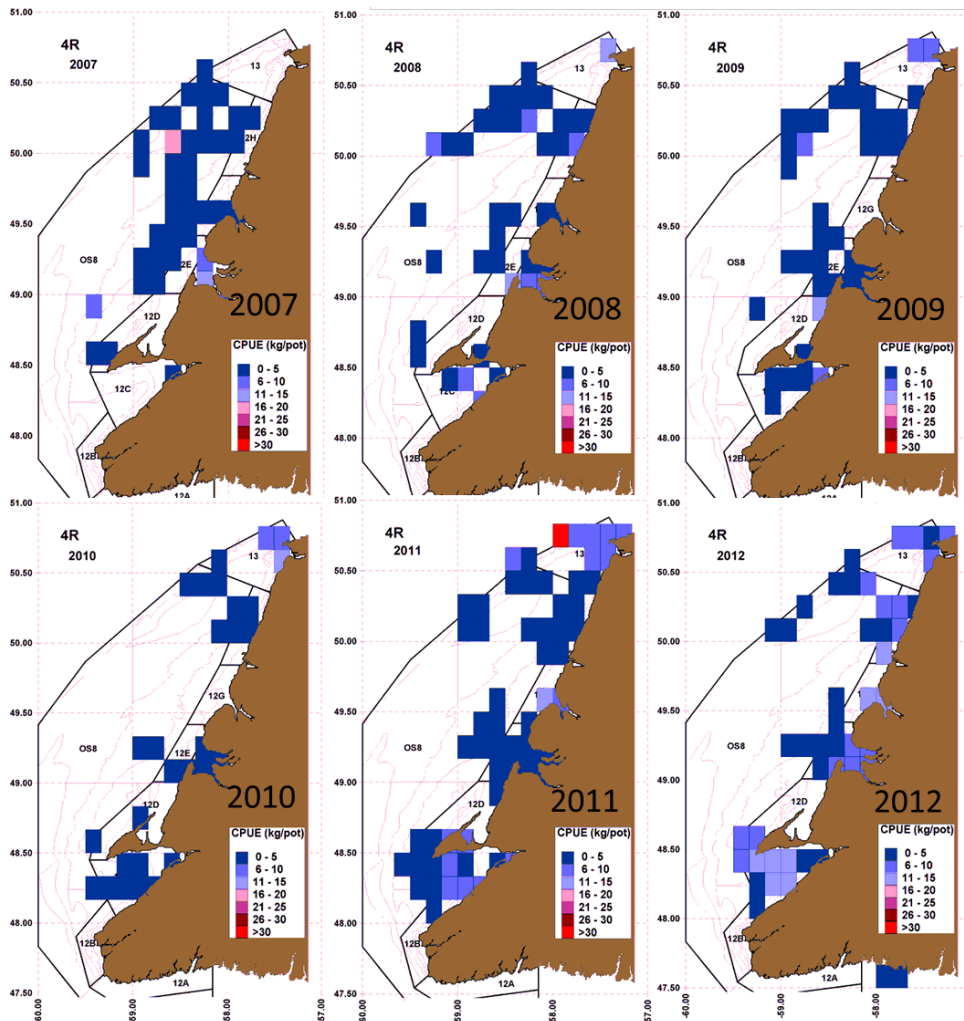


Figure 287: Spatial distribution of Div. 4R offshore logbook CPUE by year.

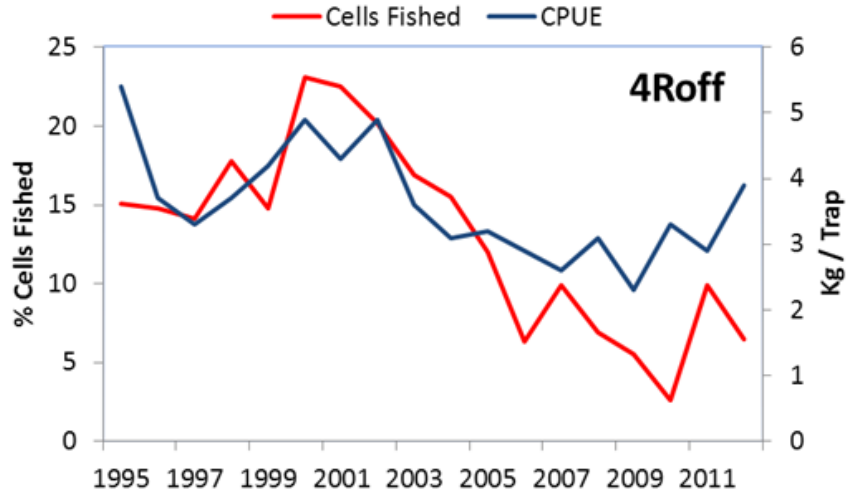


Figure 288: Trends in Div. 4R offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

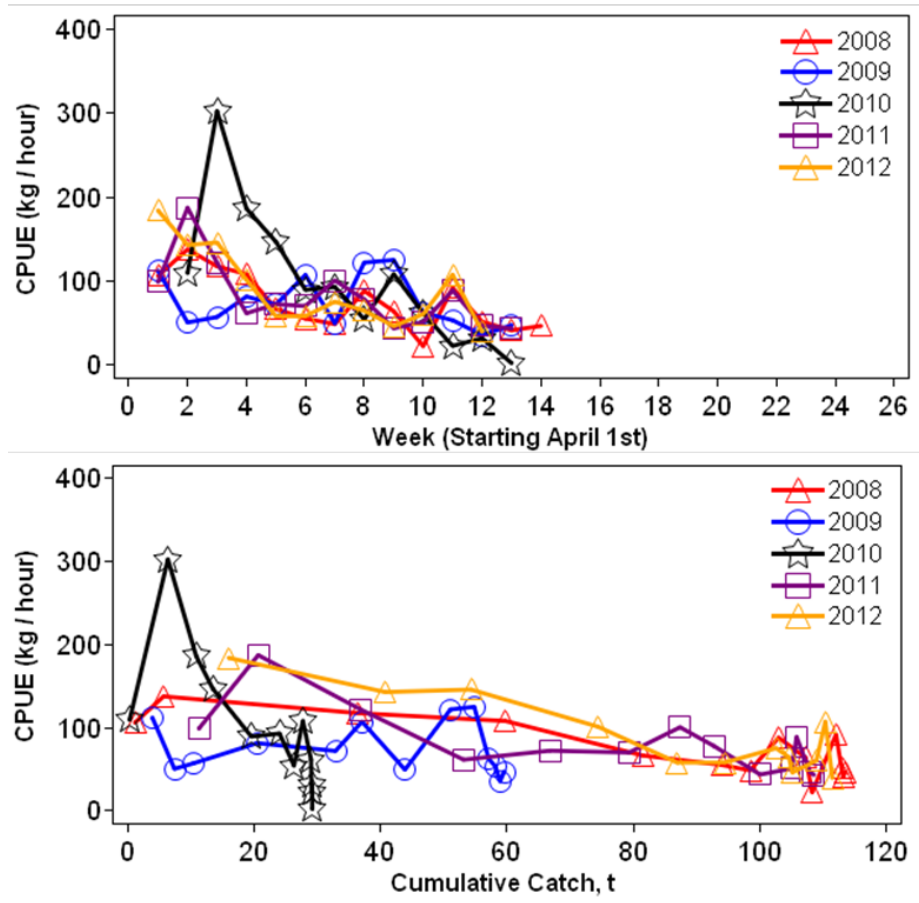


Figure 289: Seasonal trends in VMS-based CPUE for Div. 4R offshore; by week (above), and in relation to cumulative catch (below).

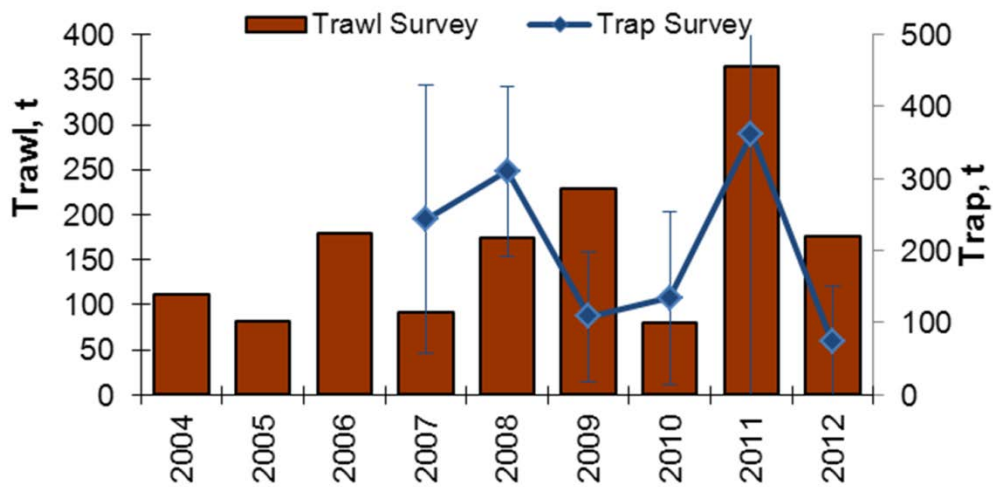


Figure 290: Trends in Div. 4R offshore summer trawl survey exploitable biomass index and the CPS trap survey exploitable biomass index.

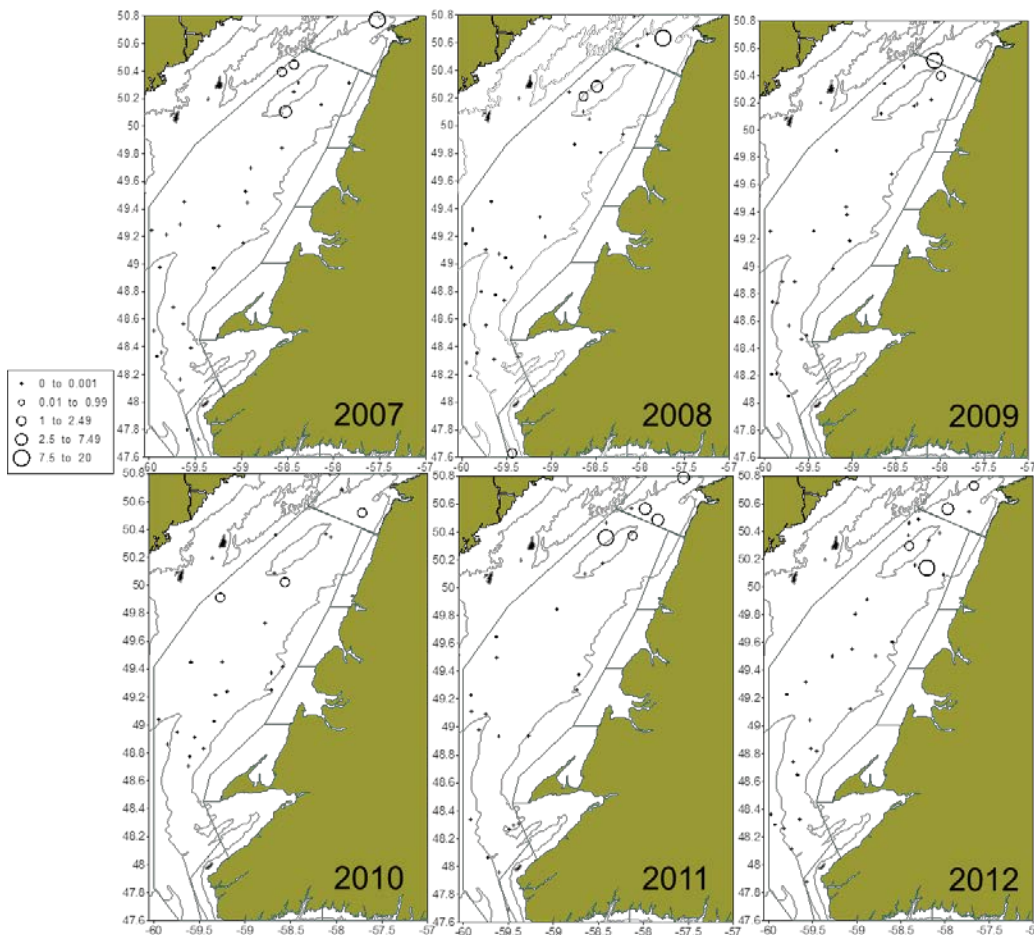


Figure 291: Spatial distribution of catches (number/set) of exploitable crab in the Div. 4R summer trawl survey.

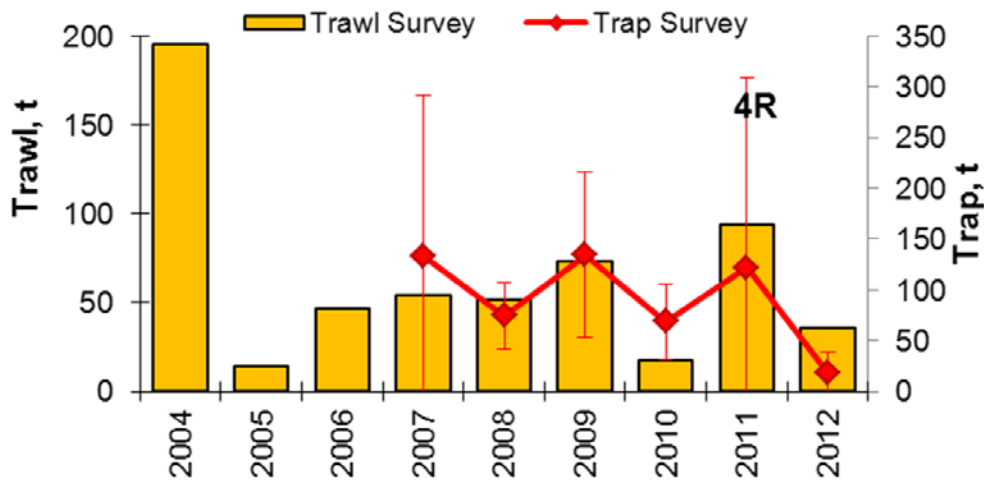


Figure 292: Trends in Div. 4R offshore summer trawl survey pre-recruit biomass index and the CPS trap survey pre-recruit biomass index.

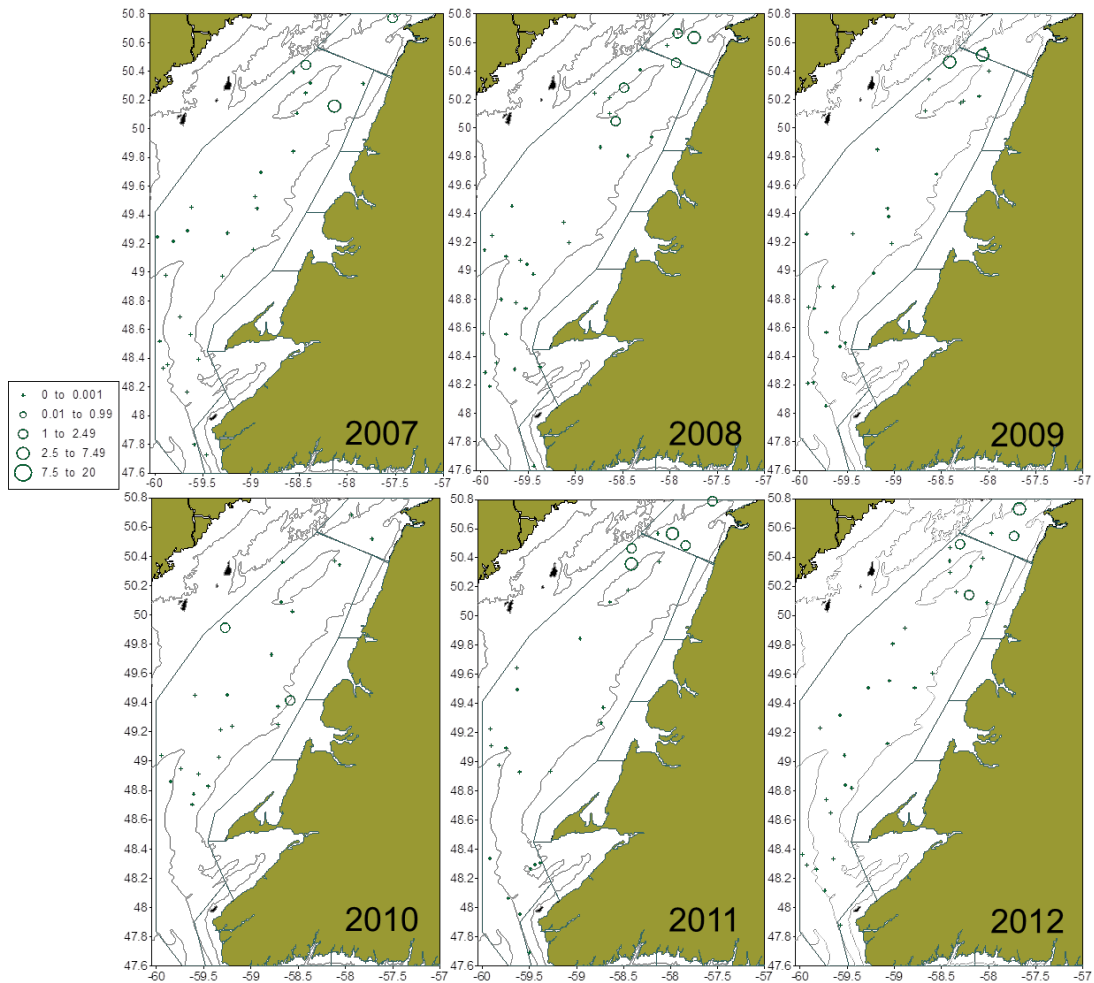


Figure 293: Spatial distribution of catches (number/set) of pre-recruit crab in the Div. 4R summer trawl survey.

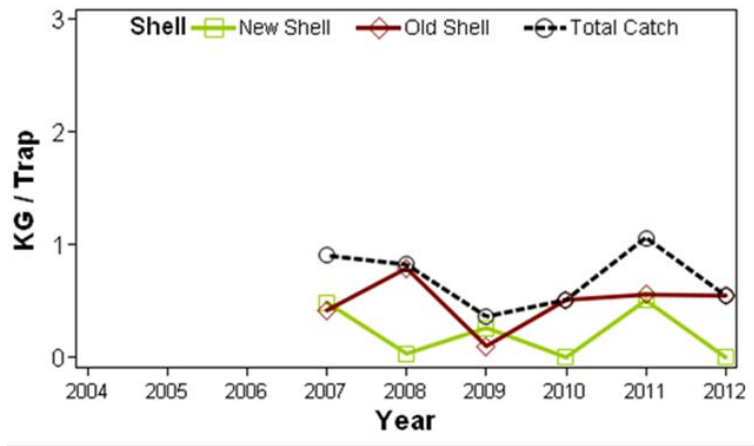


Figure 294: Trends in CPUE by shell condition for legal-sized crabs from core stations in the Div. 4R offshore CPS trap survey.

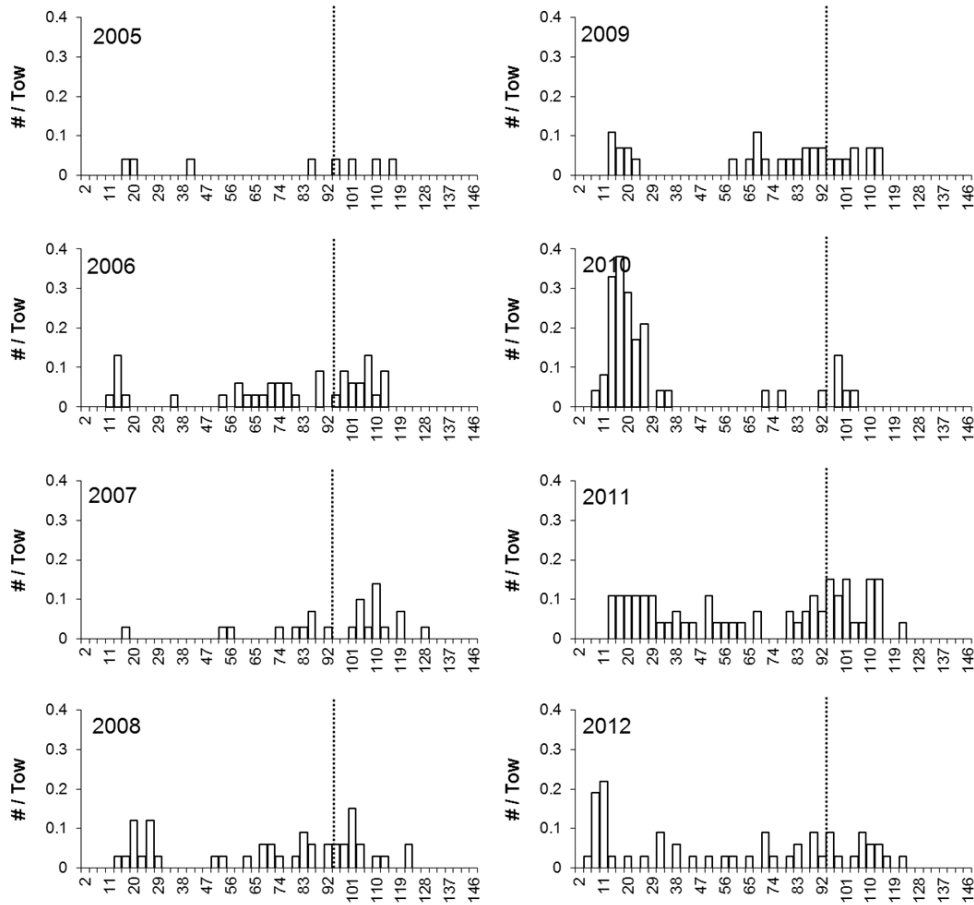


Figure 295: Abundance indices by carapace width for Div. 4R offshore male crabs from summer trawl surveys. The vertical dashed line indicates the minimum legal size.

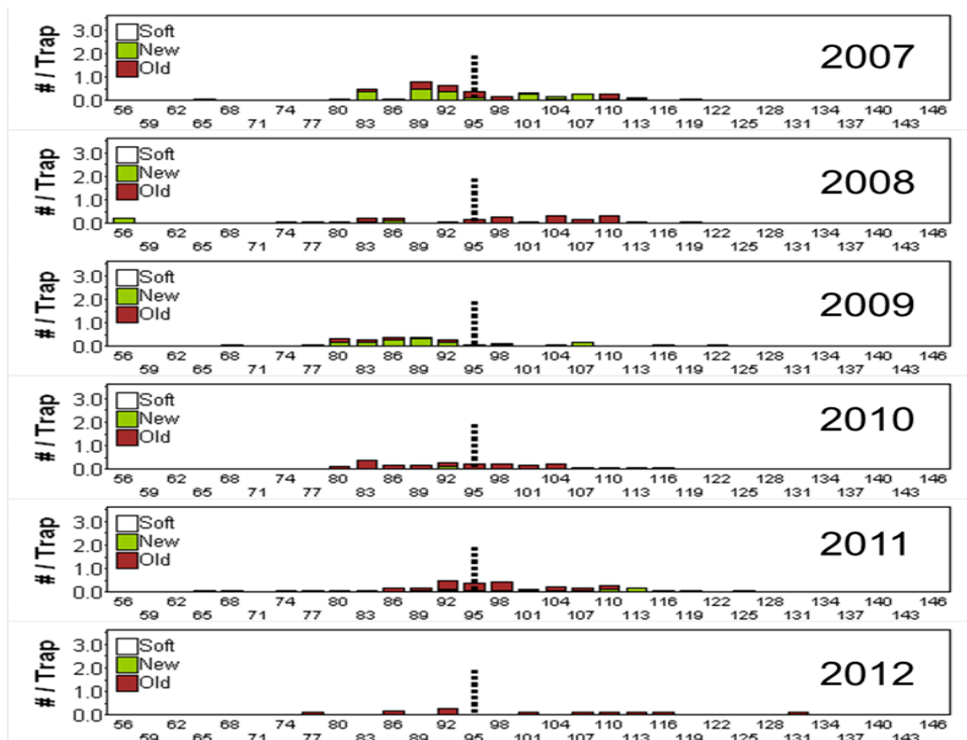


Figure 296: Trends in male carapace width distributions from core stations in the Div. 4R offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

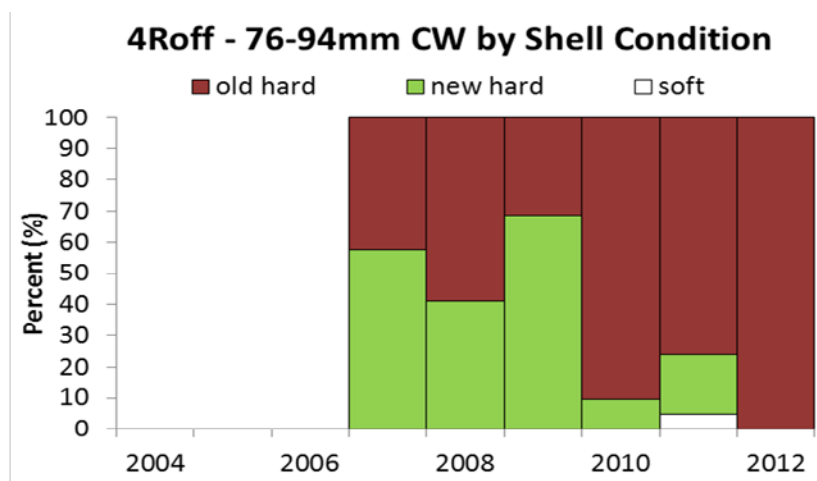


Figure 297: Trends in shell condition of 76-94mm CW crabs from Division 4R offshore CPS trap survey.

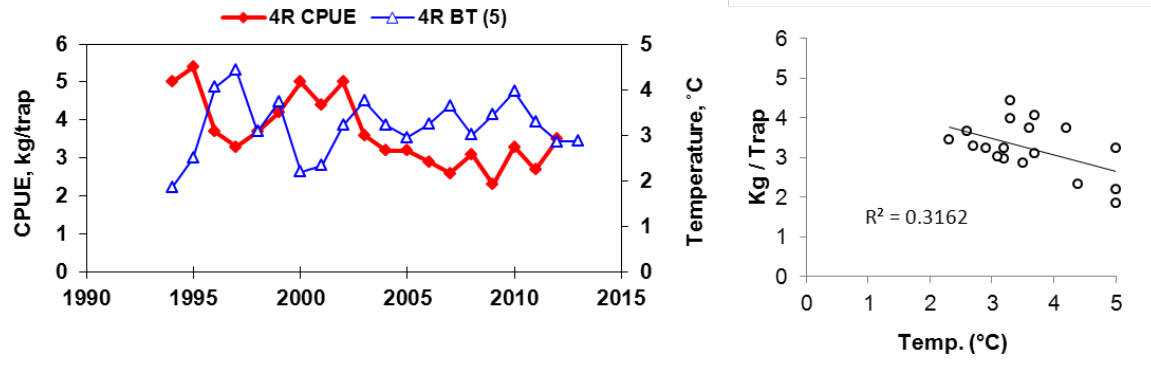


Figure 298: Trends in the Div. 4R offshore CPUE vs. bottom temperature at a five year lag (left) and corresponding scatter plot (right).

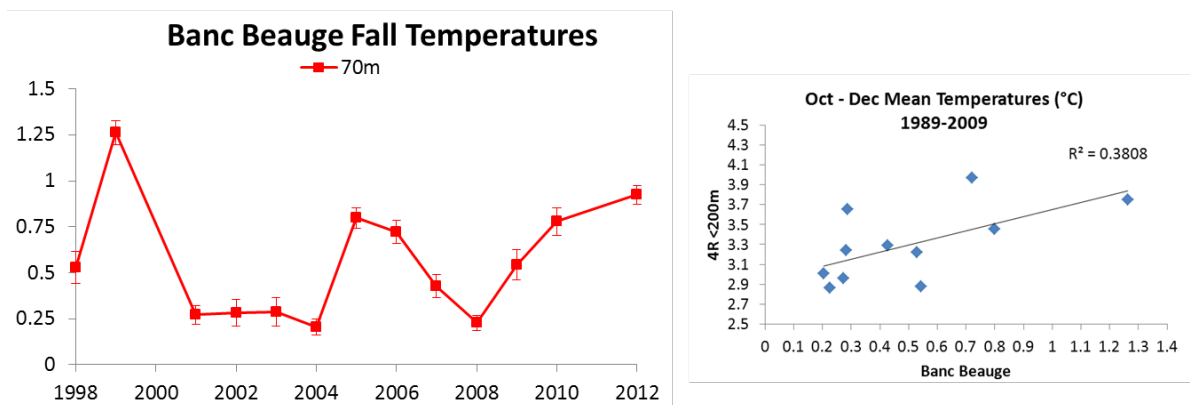


Figure 299: Trend in Banc Beauge fall bottom temperature (left) and the relationship between Banc Beauge and Div. 4R bottom temperatures from 1989-2009 (right).

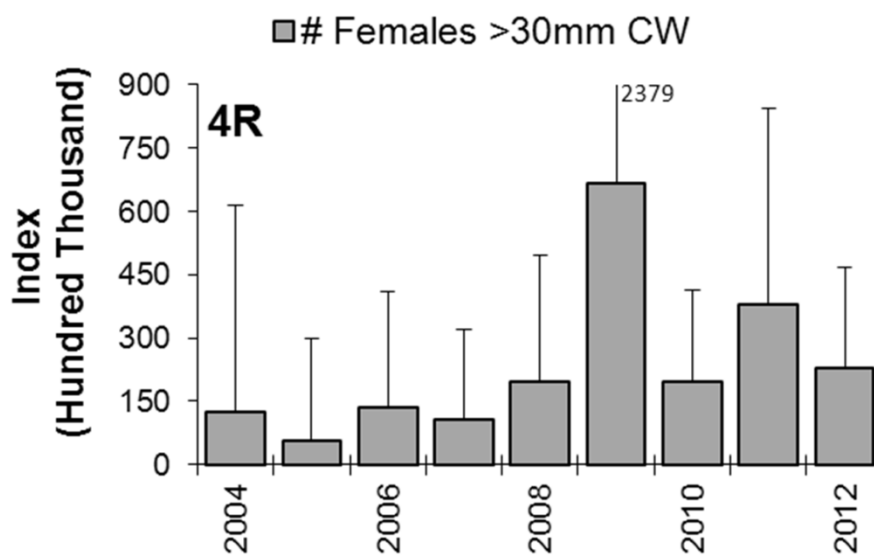


Figure 300: Trends in abundance of large females in Division 4R from summer multi-species surveys.

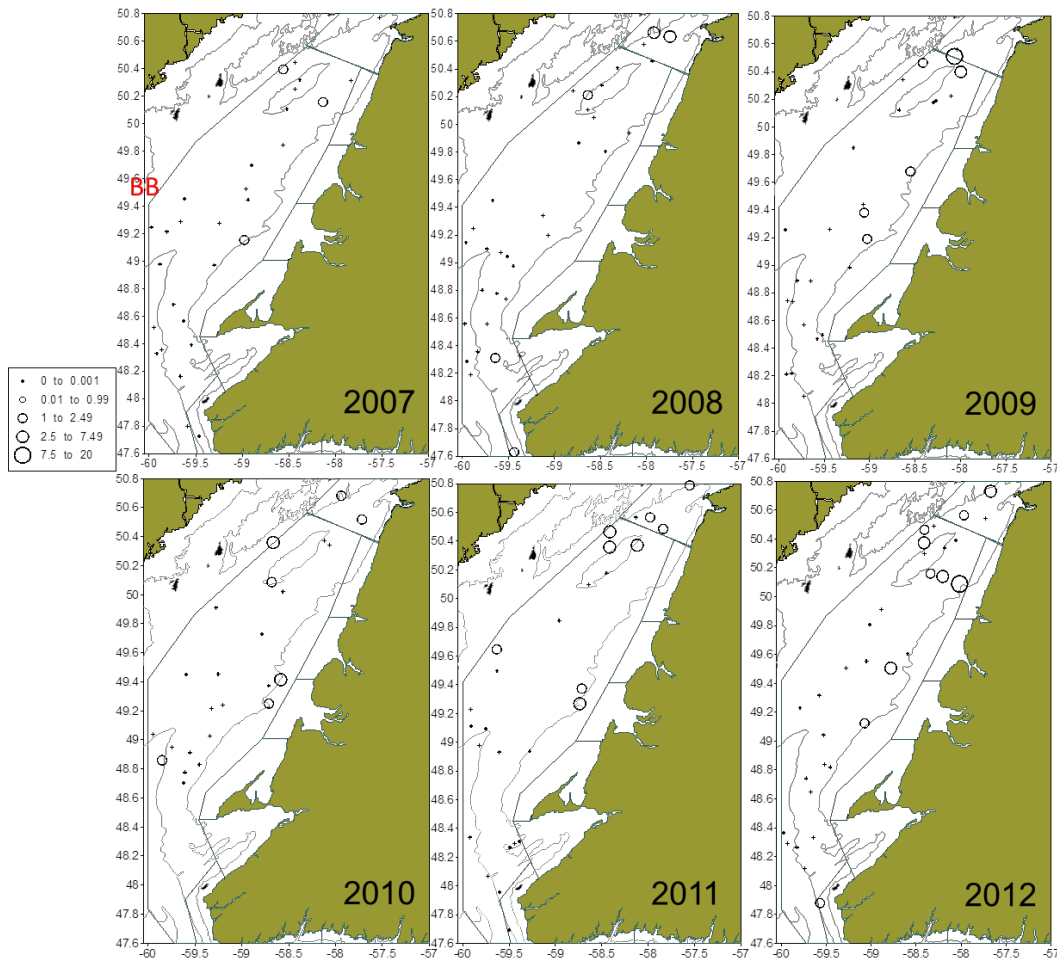


Figure 301: Spatial distribution of catches (number/set) of large female crab in the Div. 4R summer trawl survey.

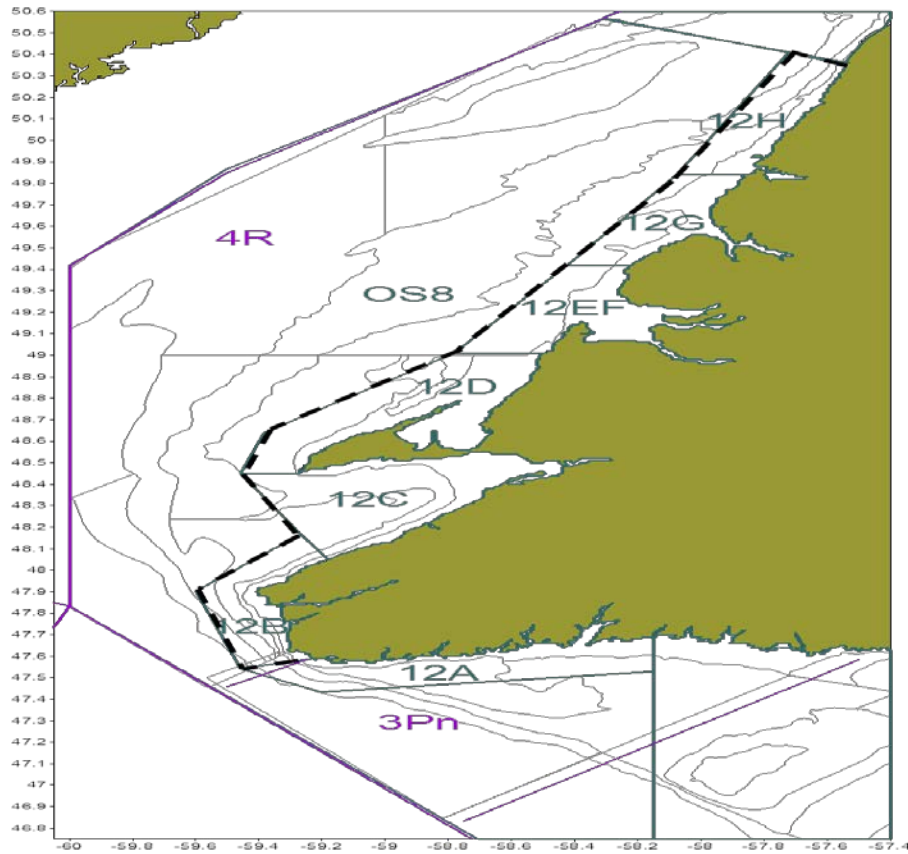


Figure 302: Map of Division 4R showing crab management areas and important bathymetric features. Dashed perimeter indicates inshore areas.

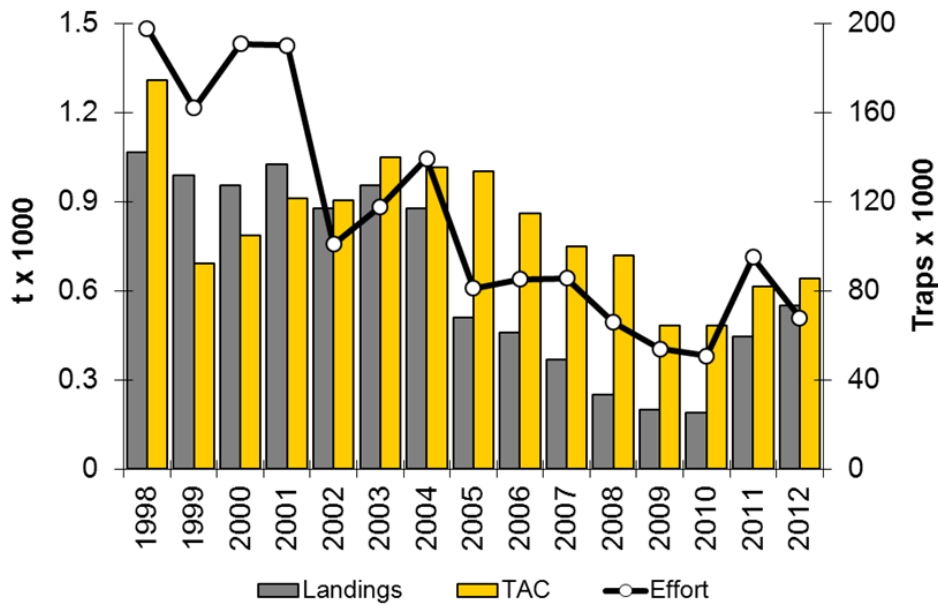


Figure 303: Trends in Div. 4R inshore landings, TAC, and fishing effort.

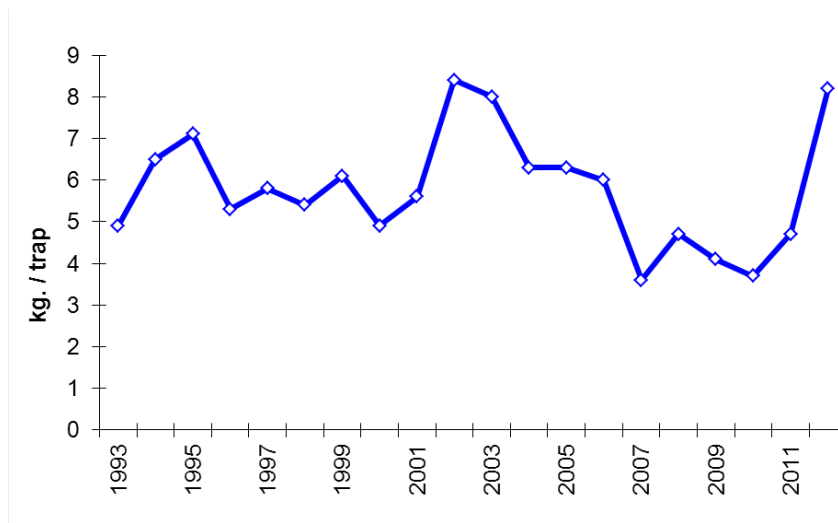


Figure 304: Trend in commercial logbook CPUE in the Div. 4R inshore fishery.

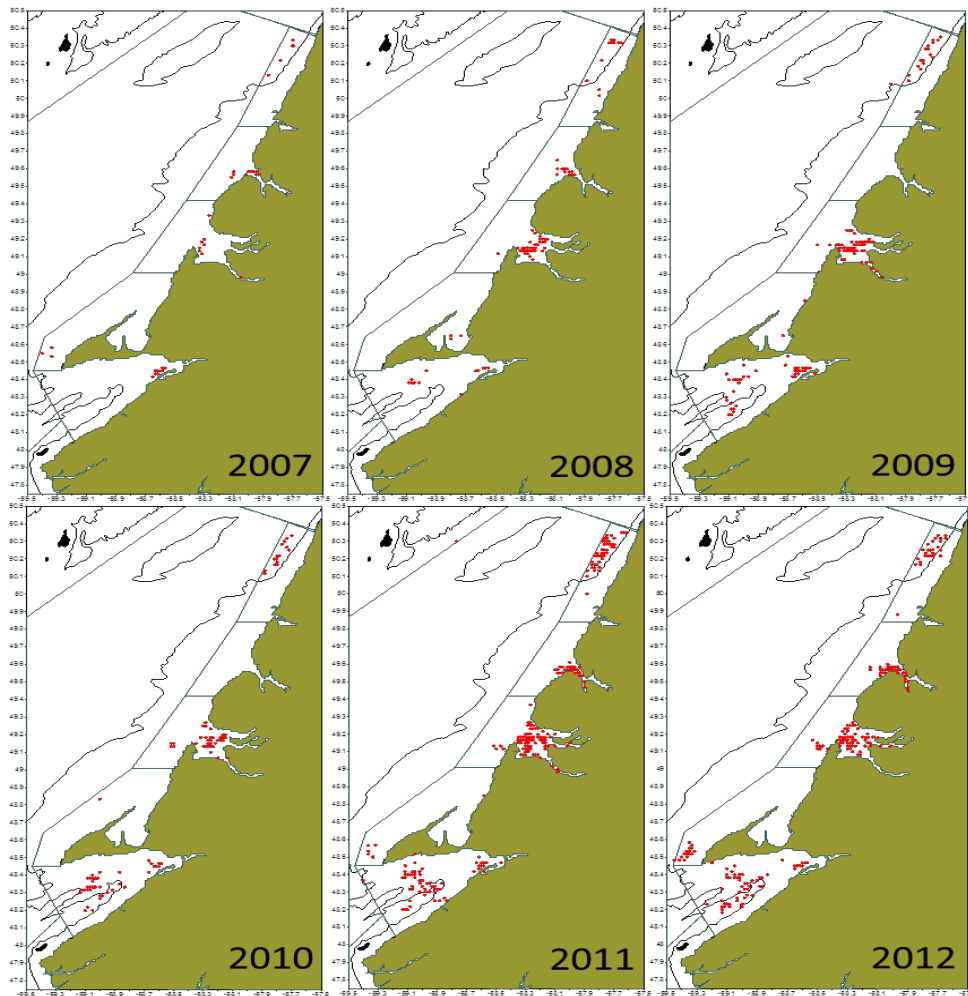


Figure 305: Spatial distribution of the Div. 4R inshore fishing effort by year.

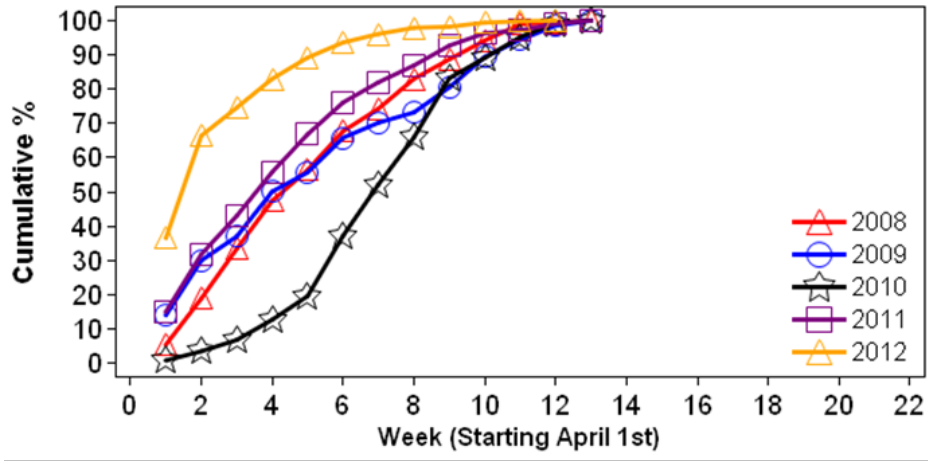


Figure 306: Seasonal trends in weekly fishing effort for Div. 4R inshore.

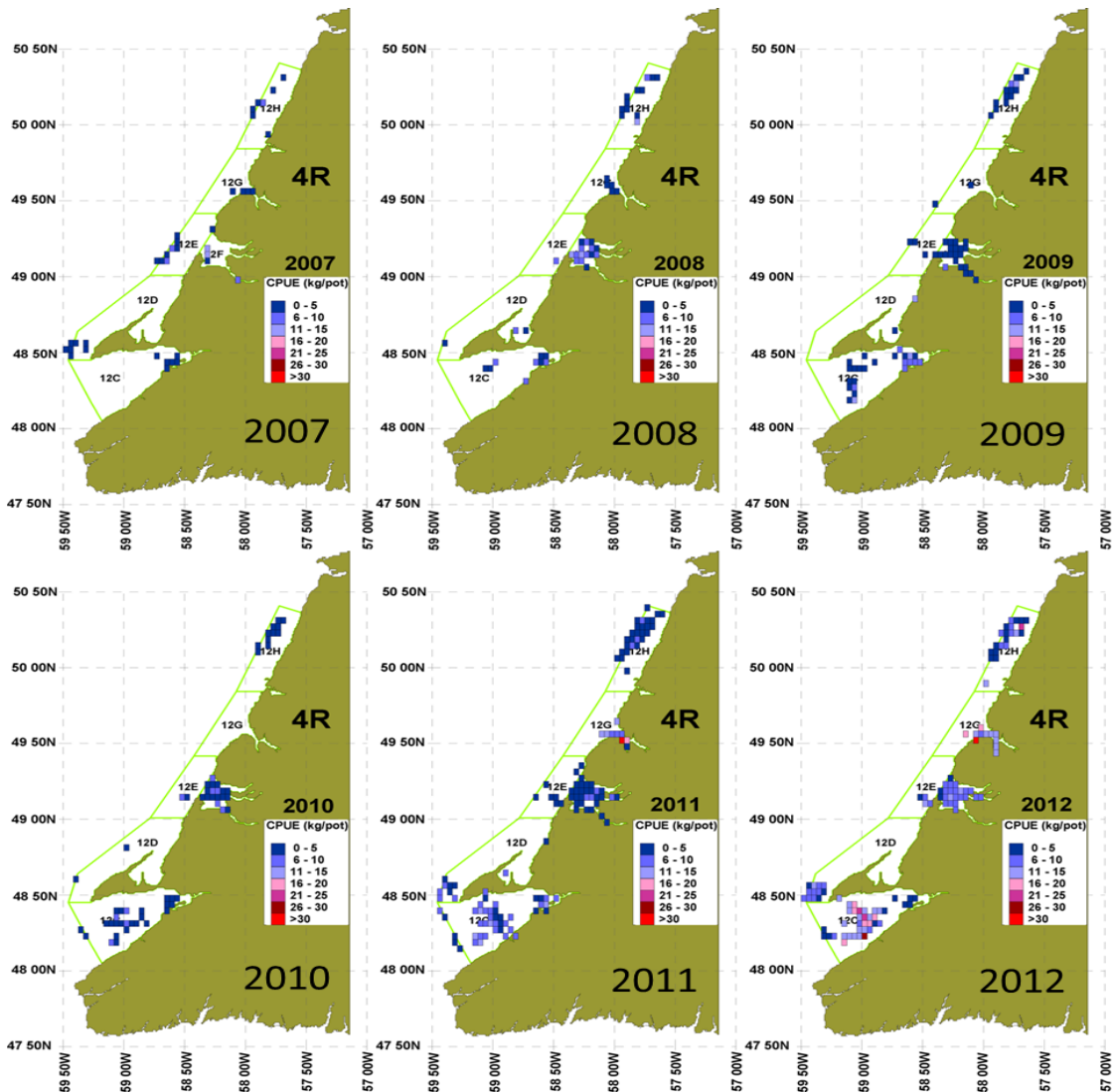


Figure 307: Spatial distribution of Div. 4R inshore logbook CPUE by year.

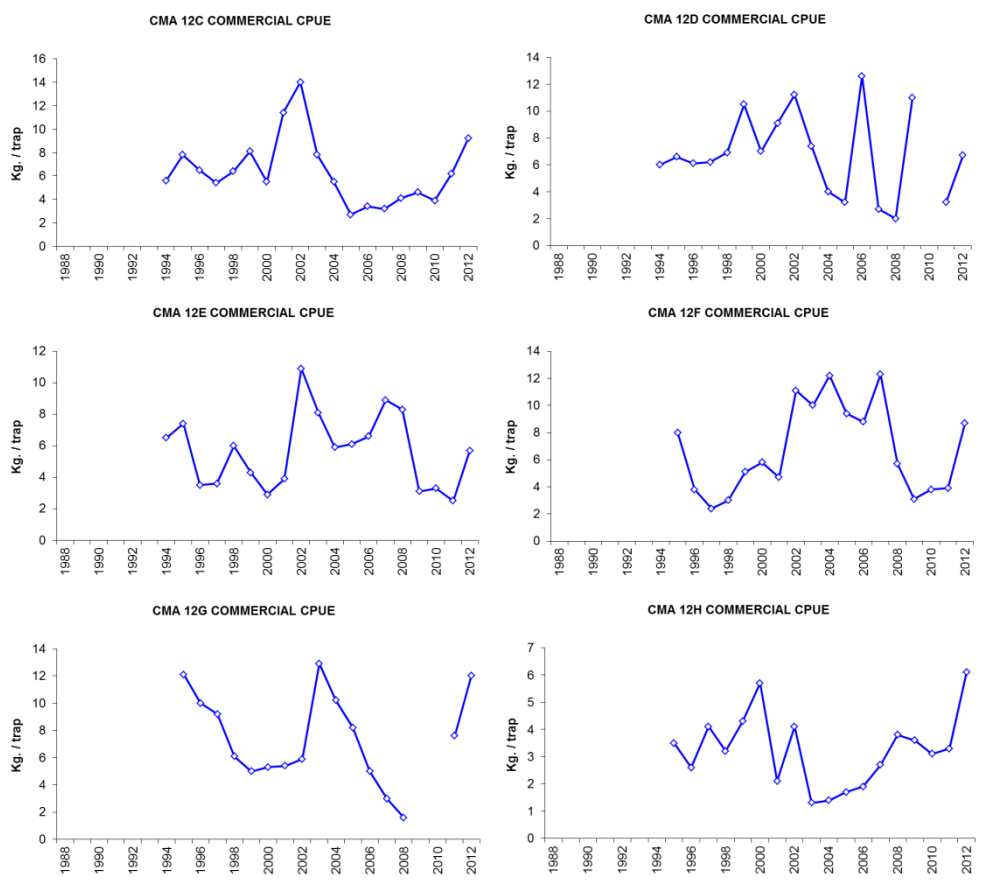


Figure 308: Trends in Division 4R inshore logbook CPUE by Crab Management Area.

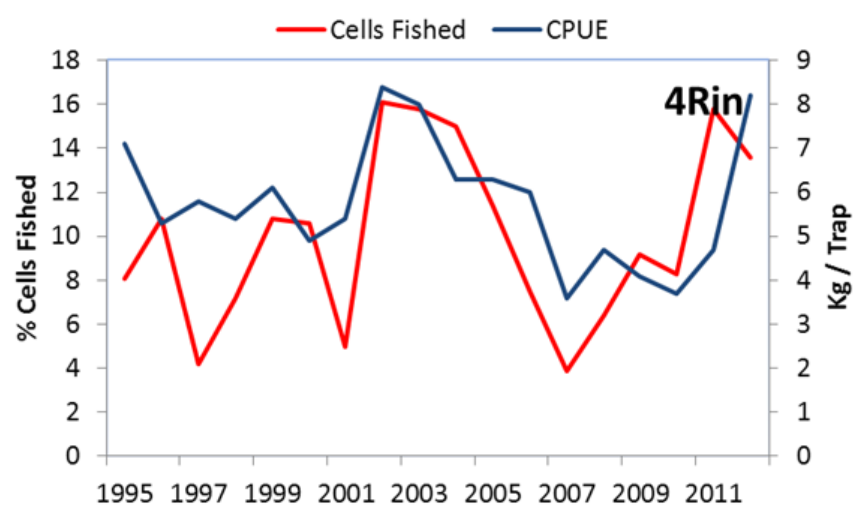


Figure 309: Trends in Division 4R inshore logbook CPUE vs. the percentage of 5' x 5' cells fished.

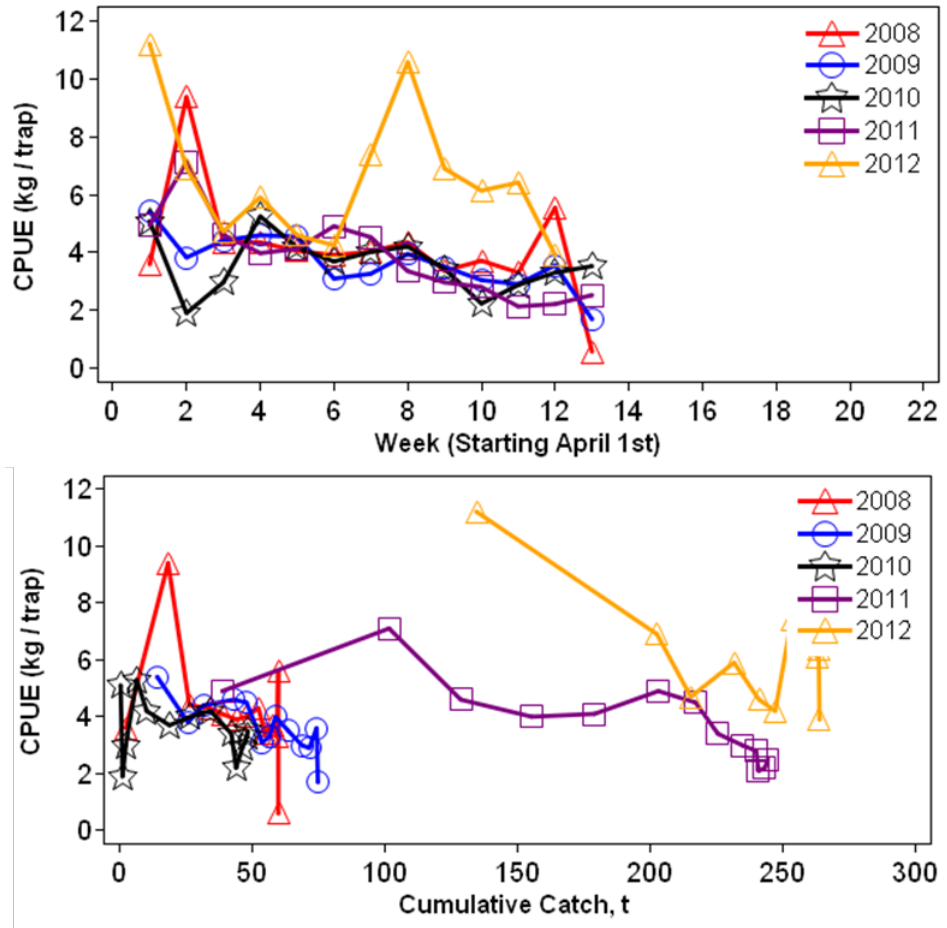


Figure 310: Seasonal trends in logbook-based CPUE for Division 4R inshore; by week (above), and in relation to cumulative catch (below).

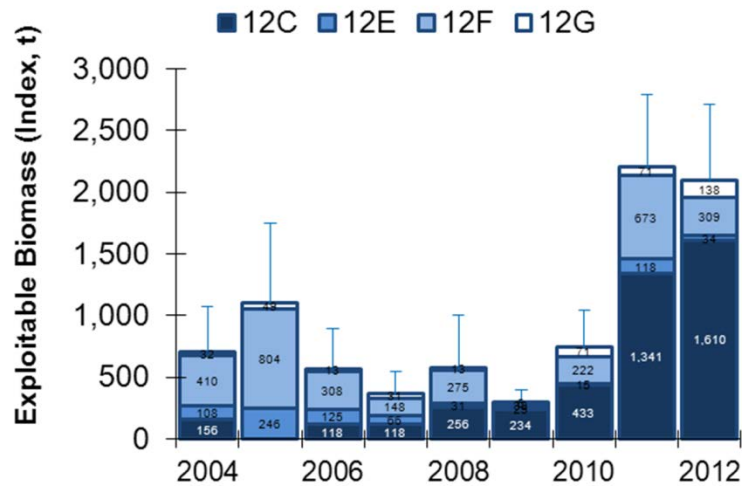


Figure 311: Exploitable biomass indices by management area from the CPS trap survey in Division 4R inshore.

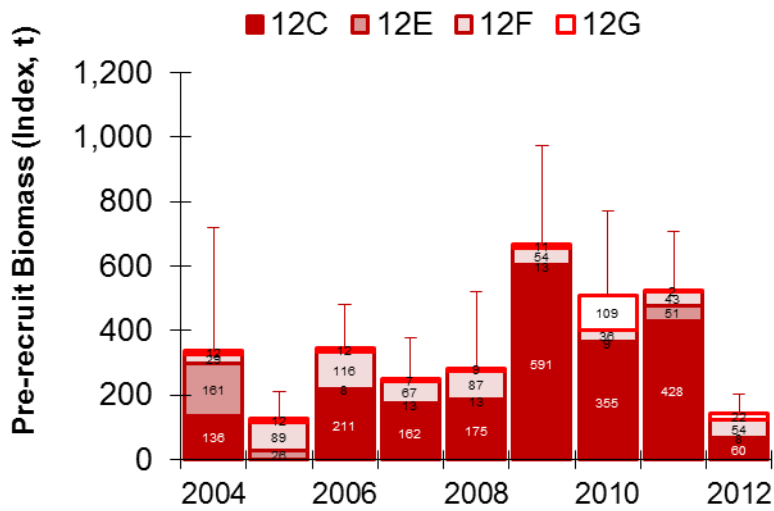


Figure 312: Pre-recruit biomass indices by management area from the CPS trap survey in Division 4R inshore.

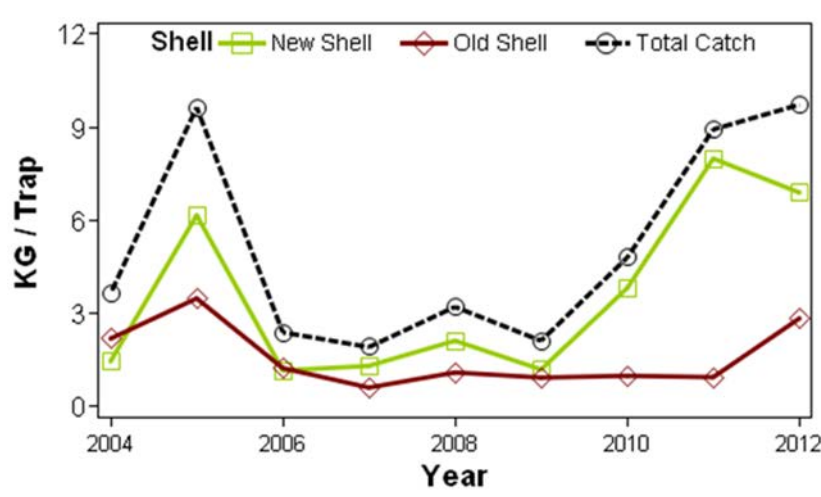


Figure 313: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in Division 4R inshore.

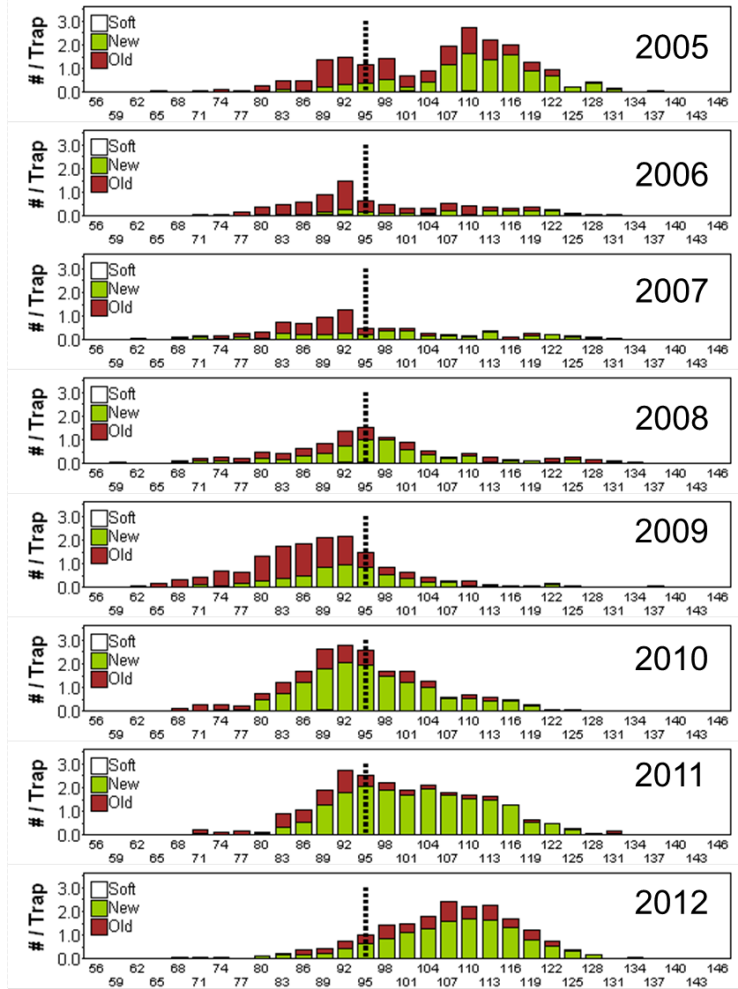


Figure 314: Trends in male carapace width distributions from core stations in the Division 4R inshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

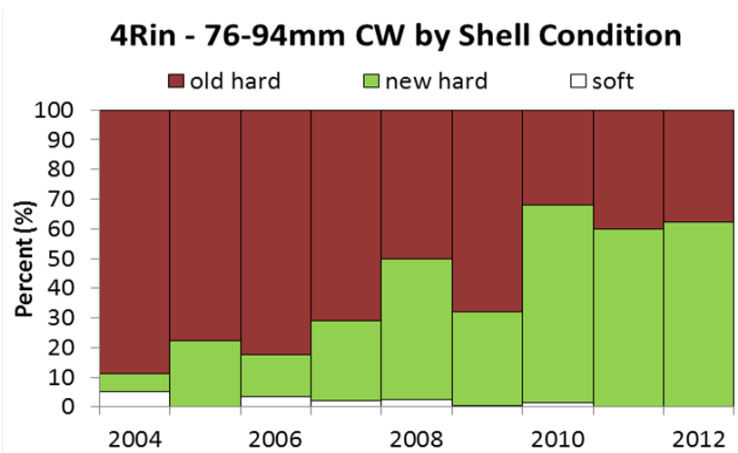


Figure 315: Trends in shell condition of 76-94mm CW crabs from Division 4R inshore CPS trap survey.

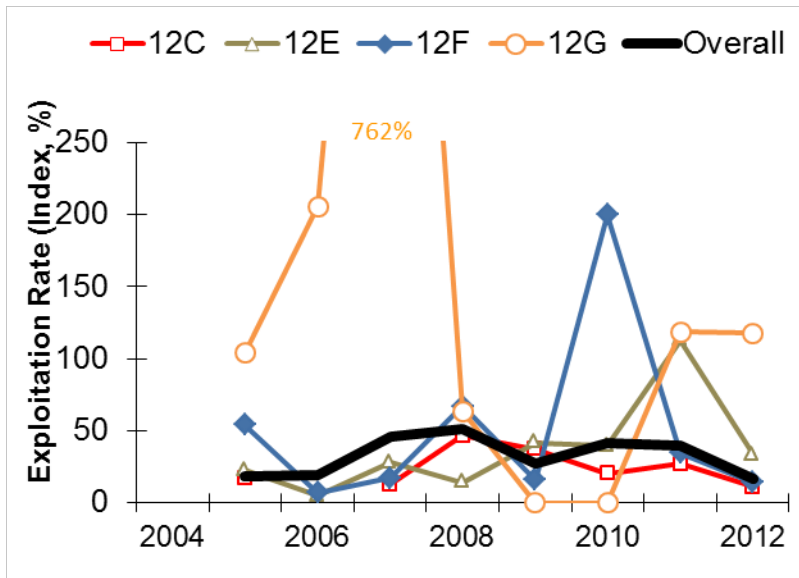


Figure 316: Exploitation rate indices by crab management area as well as overall for Div. 4R inshore based on the CPS trap survey.

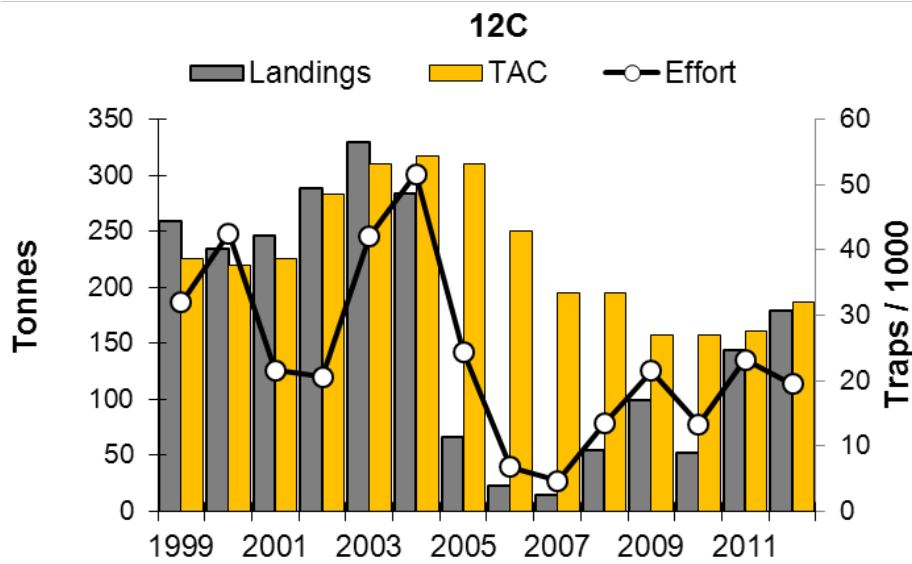


Figure 317: Trends in CMA 12C landings, TAC, and fishing effort.

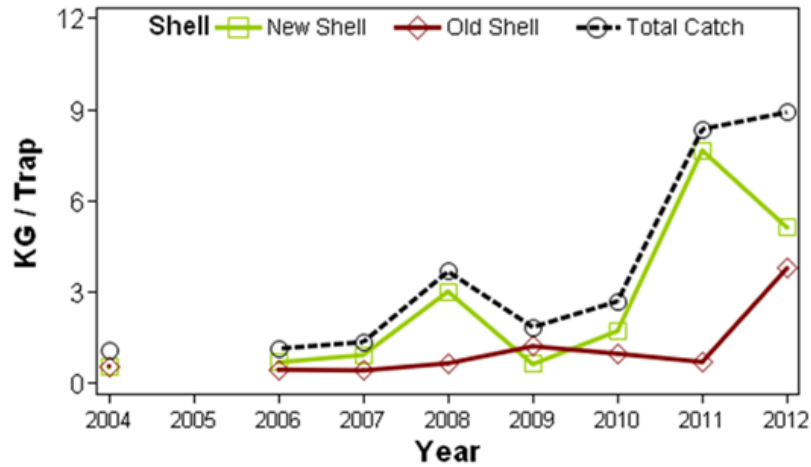


Figure 318: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 12C.

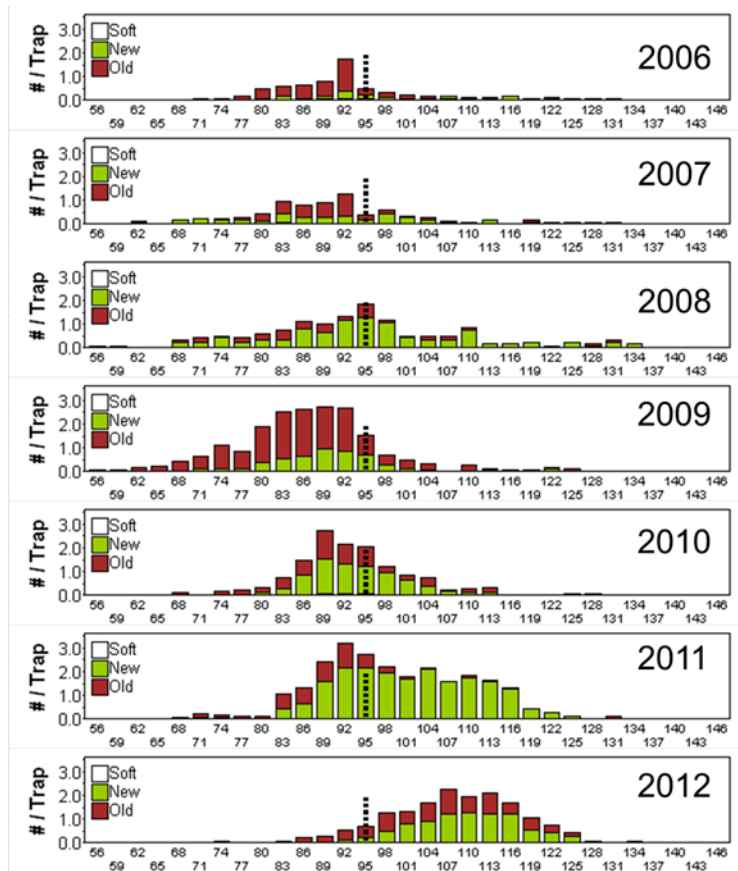


Figure 319: Trends in male carapace width distributions from core stations in the CMA 12C inshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

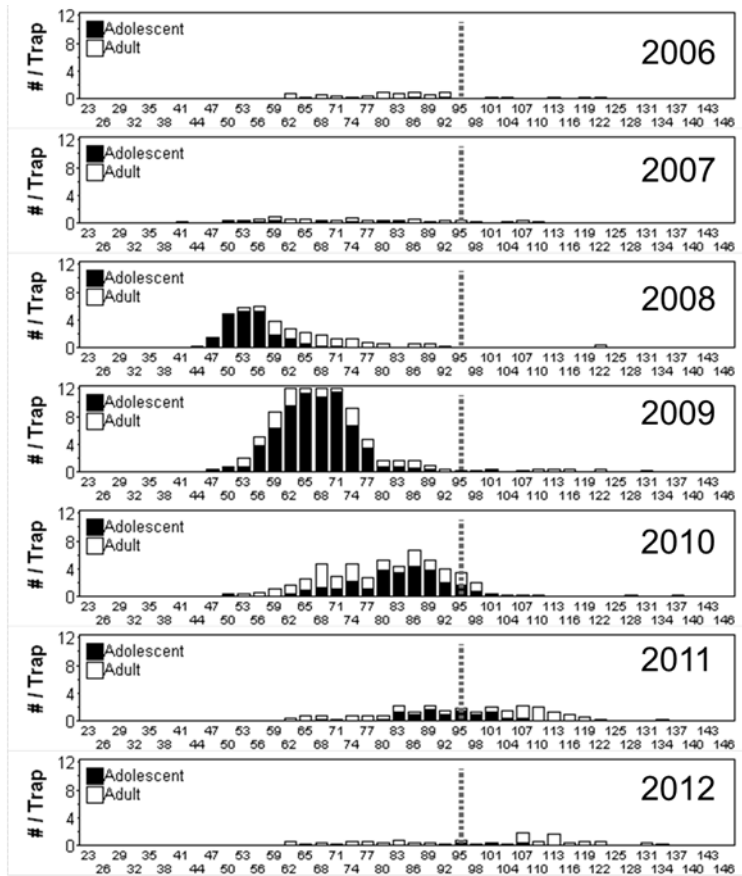


Figure 320: Trends in male carapace width distributions from small-mesh traps in CMA 12C from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

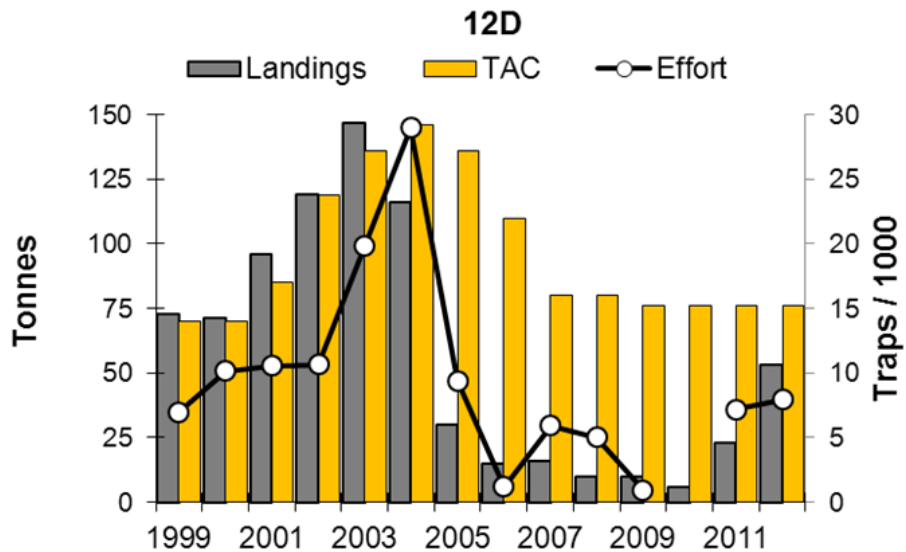


Figure 321: Trends in CMA 12D landings, TAC, and fishing effort.

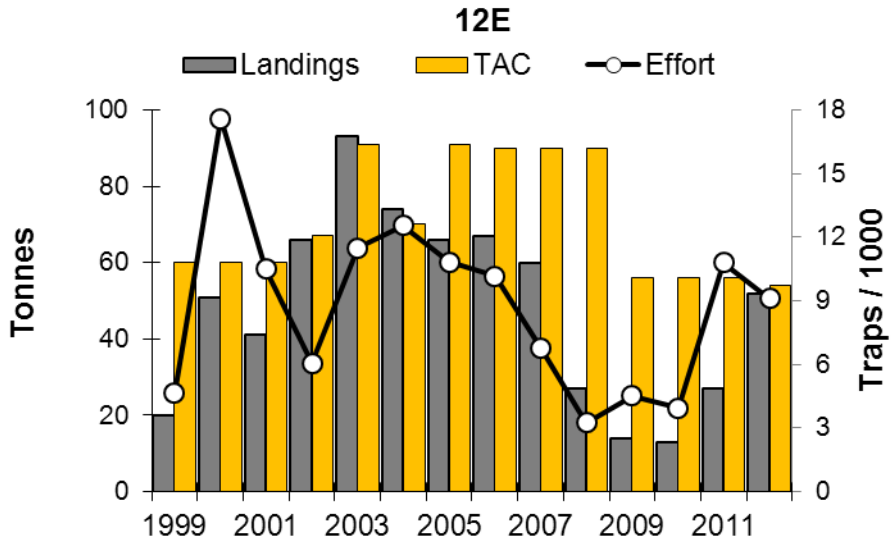


Figure 322: Trends in CMA 12E landings, TAC, and fishing effort.

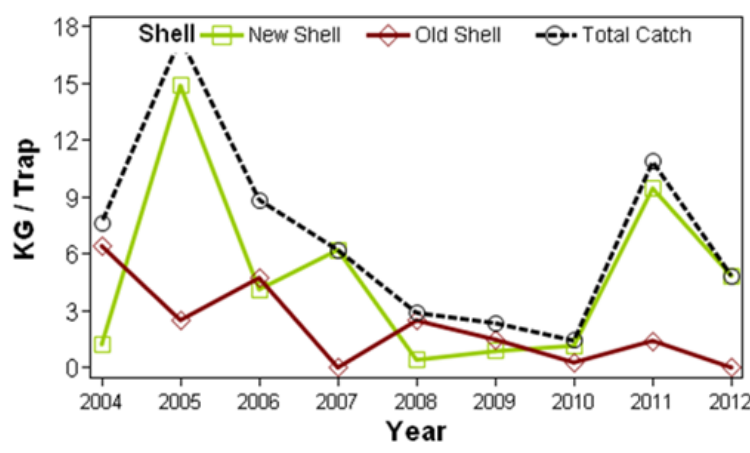


Figure 323: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 12E.

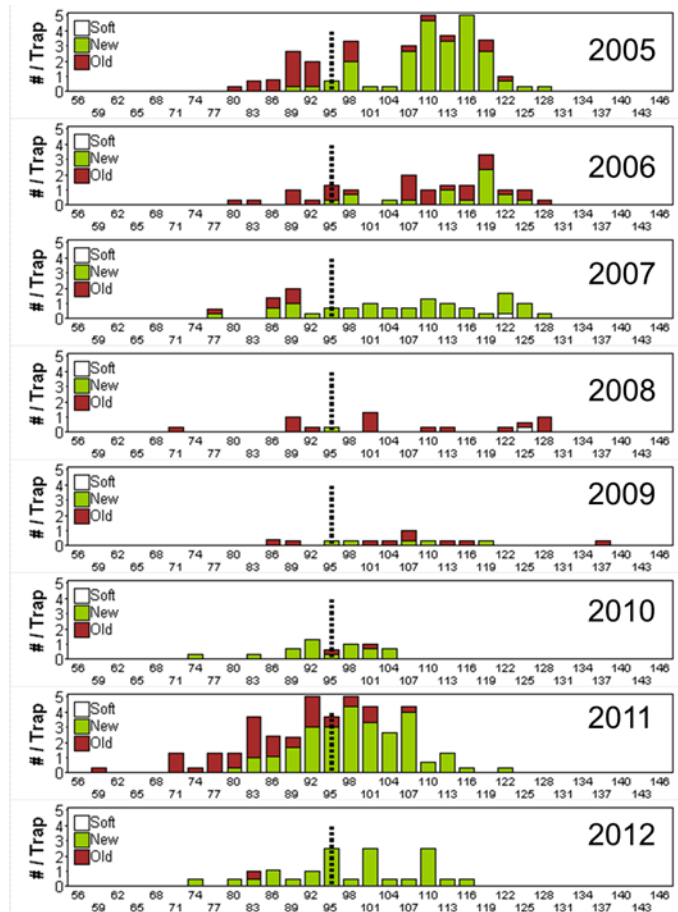


Figure 324: Trends in male carapace width distributions from core stations in the CMA 12E CPS trap survey. The vertical dashed line indicates the minimum legal size.

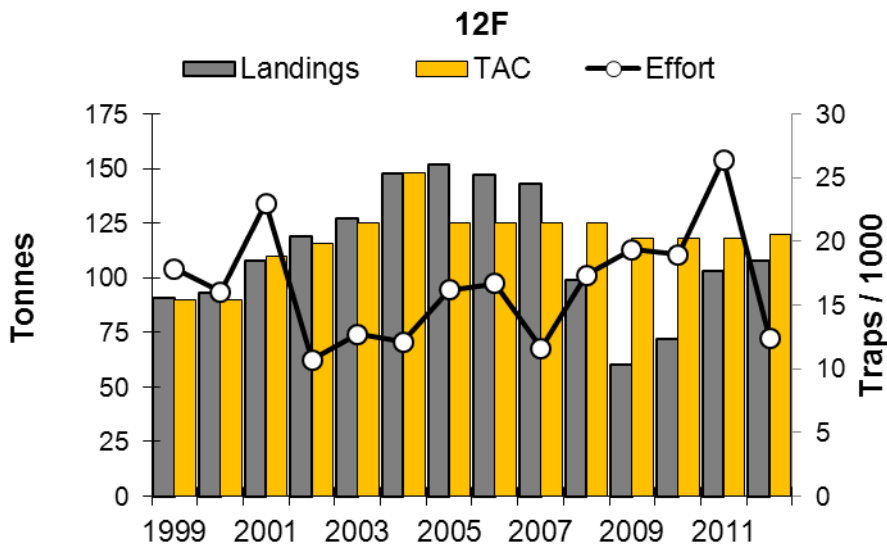


Figure 325: Trends in CMA 12F landings, TAC, and fishing effort.

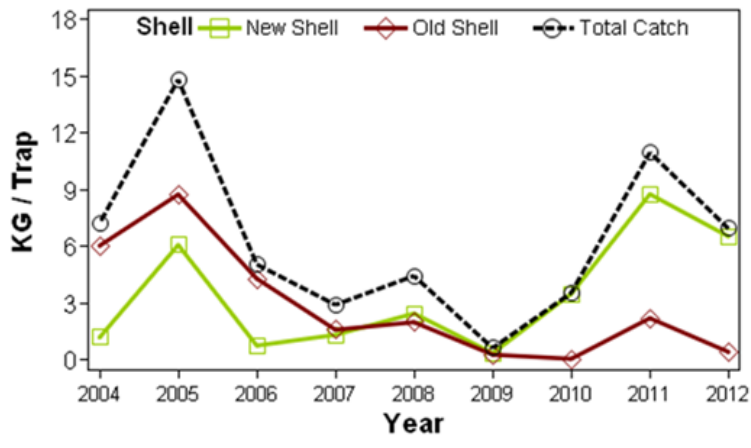


Figure 326: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 12F.

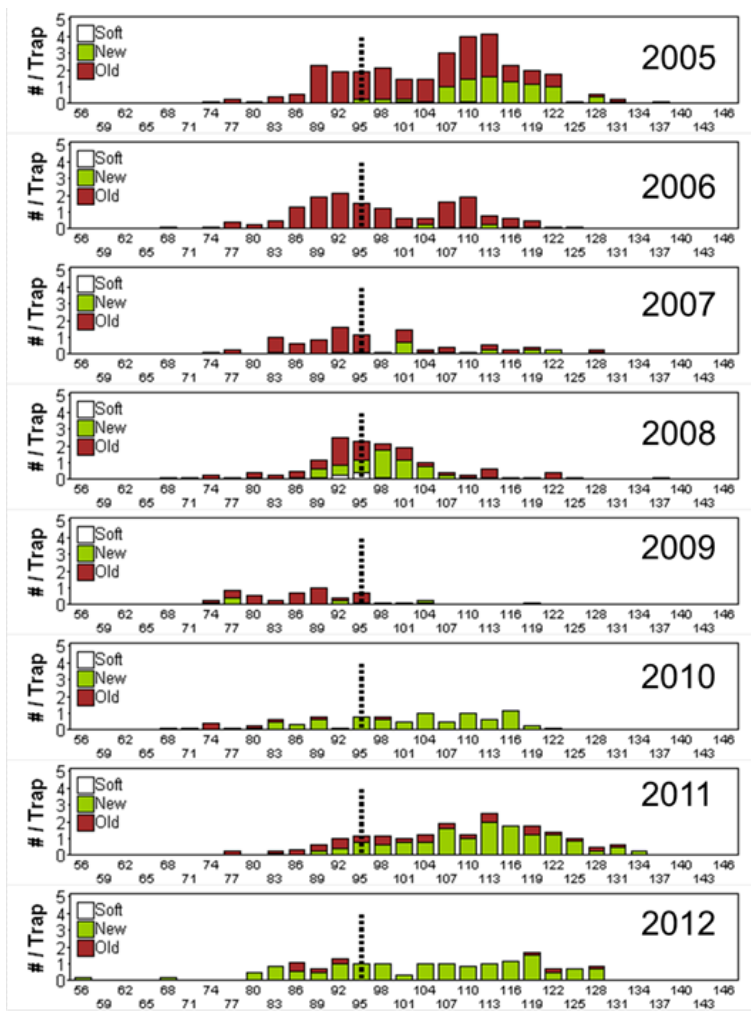


Figure 327: Trends in male carapace width distributions from core stations in the CMA 12E CPS trap survey. The vertical dashed line indicates the minimum legal size.

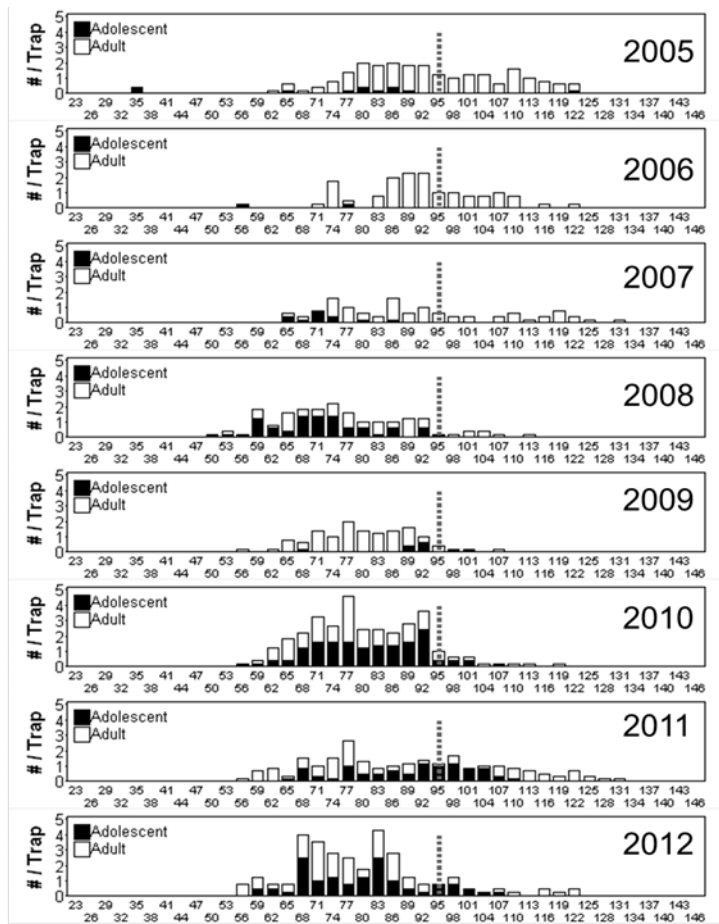


Figure 328: Trends in male carapace width distributions from small-mesh traps in CMA 12F from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

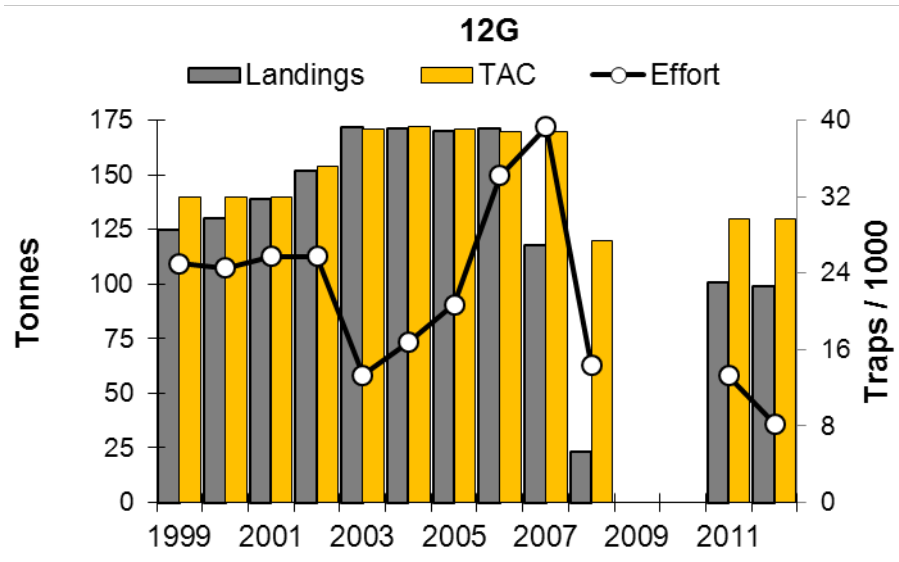


Figure 329: Trends in CMA 12G landings, TAC, and fishing effort.

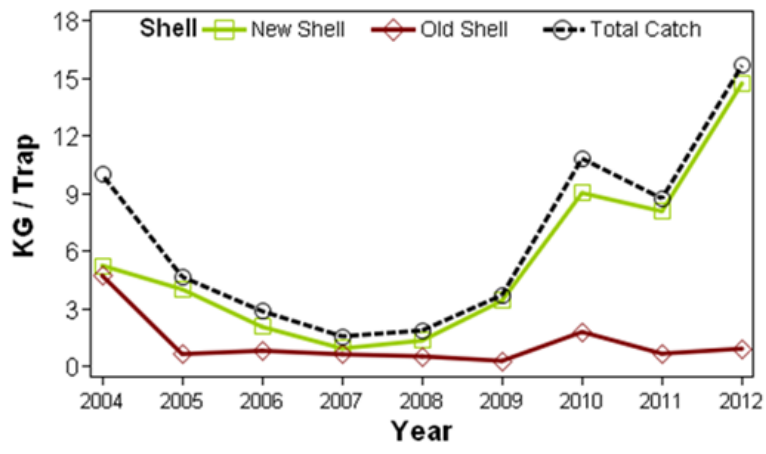


Figure 330: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 12G.

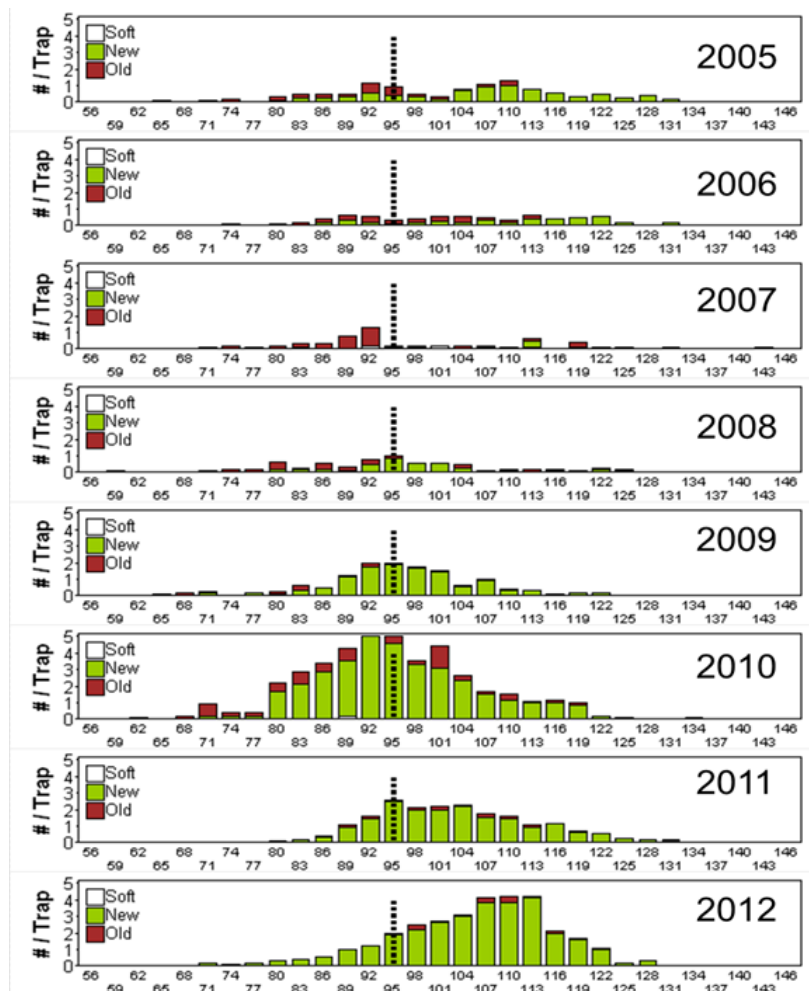


Figure 331: Trends in male carapace width distributions from core stations in the CMA 12G CPS trap survey. The vertical dashed line indicates the minimum legal size.

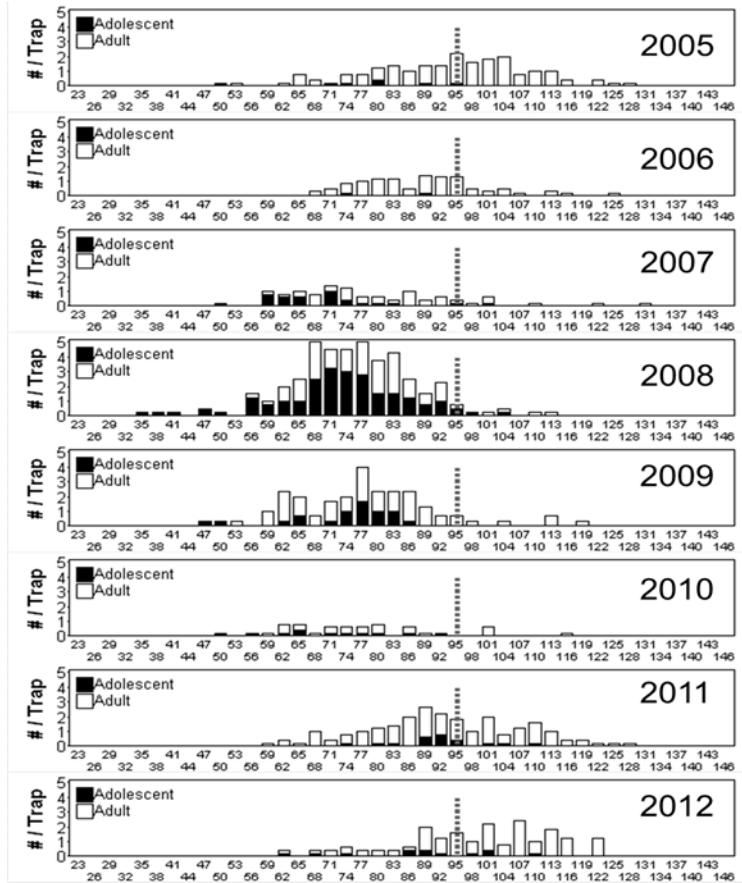


Figure 332: Trends in male carapace width distributions from small-mesh traps in CMA 12G from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

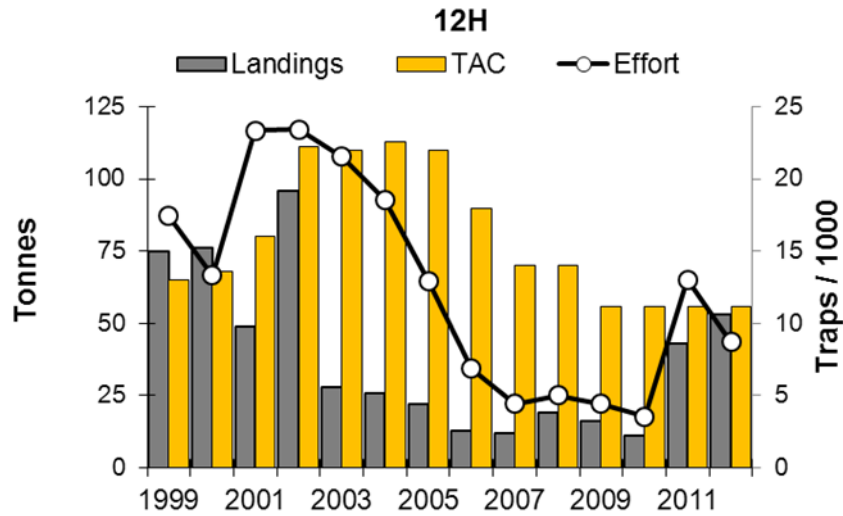


Figure 333: Trends in CMA 12G landings, TAC, and fishing effort.