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An Assessment of Newfoundland and Labrador Snow Crab (*Chionoecetes opilio*) in 2014

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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 Northwest Atlantic Fisheries Organization (NAFO) Divisions (Divs.) 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 applicable (Divs. 3KLPs). Data availability varied among divisions and between inshore and offshore areas within divisions. Trap and trawl surveys indicate that overall the exploitable biomass has recently declined and Divs. 3LNO now account for most of the biomass. Overall, recruitment has declined in recent years and is expected to decline further in the short term (two-three years) although it may improve thereafter. The emergence of a pulse of small crabs, associated with cooling oceanographic conditions in the past three years, suggest a modest increase in recruitment within some NAFO Divisions in about six to eight years. However, a warm oceanographic regime suggests weak recruitment in the longer term. 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 2014

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. On a évalué la ressource des zones du large et des zones côtières séparément pour chaque division de l'OPANO, le cas échéant (division 3KLPs). 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 au casier et au chalut indiquent que, dans l'ensemble, la biomasse exploitable a récemment diminué et que les divisions 3LNO représentent maintenant la majorité de la biomasse. Dans l'ensemble, le recrutement a diminué au cours des dernières années et devrait continuer à diminuer à court terme (de deux à trois ans), mais il pourrait ensuite s'améliorer. L'émergence d'un grand nombre de petits crabes, associée au refroidissement des conditions océanographiques au cours des trois dernières années, laisse supposer que certaines divisions de l'OPANO ont connu une légère augmentation du recrutement pendant environ six à huit ans. Toutefois, un régime océanographique chaud semble indiquer un faible recrutement à long terme. 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 the Northwest Atlantic Fisheries Organization (NAFO) Divisions (Divs.) 2HJ3KLNOP4R. The information presented follows from a formal scientific assessment conducted during February 2015, focused upon determining changes in the exploitable biomass of crabs available to the 2015 fishery (commencing in April 2015), 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 six to twelve 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, Mullowney et al. 2014a). Growth rates are also affected by temperature, with older age-at-recruitment 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 in the fishery is 95 mm carapace width (CW). This regulation excludes females from the fishery and ensures a portion of 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), the spatial scale at which quotas are allocated, while accommodating different types and amounts of available information.

The NL Snow Crab fishery began in 1967 and was limited to NAFO Divs. 3KL until the mid-1980s. It expanded throughout Divs. 2HJ3KLNOP4R from the 1970s to 2000s, especially following groundfish stock collapses in the early 1990s, and is now prosecuted by several offshore and inshore fleet sectors. Management of the increasingly diverse fishery during the expansion years led to the development of many quota-controlled areas, with about 3,500 active licence holders participating in the fishery in the mid-2000s. Resource declines and rationalization measures have led to reduced participation in recent years, with about 2,700 license holders under enterprise allocation in 2014. 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 (Fig. 3), conducted during fall in Divs. 2HJ3KLNO, and spring in Divs. 3LNOPs 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 toward inferring changes in resource status for 2015 and beyond. These other indices are derived utilizing data from harvester logbooks, at-sea observers, vessel monitoring system (VMS), the dockside monitoring program (DMP), and inshore and offshore trap surveys, as well as oceanographic surveys.

The Snow Crab resource declined during the early 1980s but recovered and remained very large throughout the 1990s. The multi-species trawl surveys indicate the overall exploitable biomass has been lower since 2000 than it had been during the 1990s. In the most recent years, both trap and trawl surveys indicate that Divs. 3LNO has accounted for most of the biomass.

The densest broad-scale aggregations of large Snow Crab in recent years have occurred on the northern Grand Bank in the cold Downing Basin (Figs. 4-5) and represents the most expansive area of high population productivity along the shelf.

Survey data also indicate that overall, recruitment is expected to decline in the short term (2-3 years). Although the recent emergence of a pulse of small crabs, associated with cooling oceanographic conditions in the past three years, suggests a modest increase in recruitment within some NAFO divisions in about six to eight years, a warm oceanographic regime suggests weak recruitment in the longer term. Declines in the exploitable biomass and fishery have recently occurred in the northernmost (Divs. 2HJ3K) and southernmost (Subdiv. 3Ps) divisions, although some recovery occurred in Div. 2J in 2015, and there are concerns of a forthcoming decline in the most productive areas (Divs. 3LNO).

METHODOLOGY

MULTI-SPECIES TRAWL SURVEY DATA

Data on total catch numbers and weights were derived from depth-stratified multi-species bottom trawl surveys (Fig. 3) conducted during fall in Divs. 2HJ3KLNO and spring in Divs. 3LNOPs. The trawl used in these 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 2010-14. Snow Crab sampling during spring Divs. 3LNOPs surveys did not begin until 1996. 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 during spring when mating and molting take place. Fall trawl surveys are thought to have the highest catchability for Snow Crab. 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. The 2004 and 2014 Divs. 3LNO fall survey, and the 2006 Subdiv. 3Ps spring survey, were incomplete and have been omitted from analyses.

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 carapace width (CW, mm) and 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;
3. intermediate-shelled – these crab last molted in the previous year and are fully recruited to the fishery throughout the current fishing season; and
4. old-shelled – these crab have been available to the fishery for at least two 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 (i.e. 'blood'). Observation of cloudy or milky hemolymph supported the classification of such specimens as infected.

We examined annual changes in biomass indices of legal-sized males, by shell condition, toward evaluating the internal consistency of the data series. Males enter the legal-size group as soft-shelled crabs, after the spring molt, and remain as new-shelled 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 total abundance of crabs, the abundance of small (< 40 mm CW crabs), exploitable and pre-recruit biomasses for males, and the abundance of mature females. For spring surveys, the indices represent abundances or biomasses for the immediately upcoming (or on-going) fishery, whereas for fall (post-season) surveys they 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 fishery but would be fully recruited to the fishery in the following year.

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. three years after the fall survey year). The ratio of the exploitable to pre-recruit biomass index for each division was interpreted as an index of recruitment potential and compared to fishery discard levels to infer potential for soft-shell wastage in the fishery. 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.

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 one and varies with substrate type and crab size (Dawe et al. 2010a) as well as diel cycle. 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, as were the distributions of mature females and small crabs (< 60 mm CW).

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. 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 Divs. 2HJ3KLNOP were not included in calculating the ratios because those areas were not surveyed in all years.

To examine size composition of males, STRAP was applied to trawl survey catches grouped by 3 mm CW intervals to reflect total population abundance indices. In Divs. 2HJ3KLNOP, each size interval was partitioned, based on chela allometry, between juveniles plus adolescents (small-clawed) versus adults (large-clawed). For females, size frequency distributions were constructed for STRAP-estimated abundance of 3 mm CW groupings of immature versus mature animals, which was determined based upon visual observation of the abdomen.

FISHERY LOGBOOK DATA AND THERMAL HABITAT INDICES

Data on commercial catch (kg) and fishing effort (number of trap hauls) were obtained from vessel logbooks. These data were compiled by the Statistics Division, Policy and Economics Branch, Newfoundland Region of Fisheries and Oceans Canada (DFO). Catch per Unit of Effort (CPUE; kg/trap haul) was calculated by year and NAFO division, and by CMA where applicable. CPUE is used as an index of biomass, but it is unstandardized in that it does not account for variation in fishing practices (e.g. soak time and mesh size). 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.

In inshore areas, the number of trap hauls and total catch from logbooks was calculated for each division on a weekly basis to compare the seasonality of the distribution of effort and CPUE among years. Similarly, weekly CPUEs were compared against the weekly cumulative catch to assess the performance of the fishery against the level of removals. Logbook CPUEs were mapped for 10' x 10' (nautical minutes) cells, 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.

CPUE indices in offshore areas were correlated against annual thermal habitat indices in each division at lags of best-fit, to assess the effect of thermal regime during early life history on future fishery success. Fishery CPUE indices are correlated with exploitable biomass indices from the trawl surveys but provide longer time series, thus comparisons with the thermal habitat indices focused on CPUE as the index of biomass. The index of bottom temperature (Fig. 5) was the areal extend of cold bottom water distribution. Bottom temperatures used to make the habitat indices were isolated to shallow strata in each division (< 200 m in Div. 2J and 4R, < 300 m in 3K and < 100 m in Divs. 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 temperatures < 2 °C in Divs. 2J3K, < 0 °C in Divs. 3LNO and < 1 °C in Subdiv. 3Ps. No thermal habitat index was calculated for Div. 4R due to insufficiency of data. Thermal habitat indices for Divs. 2J3K were derived using data from fall surveys, whereas those from Divs. 3LNOPs were derived using data from spring surveys and year-round data from Station 27, a frequently sampled oceanographic station located on the approach to the harbour of St. John's, Newfoundland.

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 (1995-2014), but at-sea sampling data have only been collected since 1999. Levels of sampling are generally highest in offshore Divs. 3KLNO due to high observer coverage in those areas (Fig. 6). Sampling has been consistently low in inshore CMAs and virtually absent throughout Divs. 2H and 4R. For inclusion in the assessment, a minimum standard of 4 weeks non-consecutive coverage during the fishery was required in any given area. 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 adult males and under-sized, and soft-shelled, pre-recruits discarded in the fishery, in year t, calculated from observer sampling data. PBI is an index of the biomass of pre-recruits and under-sized adult males (t x 1000) from the preceding survey; i.e. the fall survey of the previous year for Divs. 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:

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

The PFMI overestimates pre-recruit mortality because the PBI underestimates pre-recruit biomass, as a result of low catchability of pre-recruits by the survey trawl. However, it is felt 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 of 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 carapace width (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 (10 x 7 na. nm) when the percentage of soft-shell crab reached 20%. This was reduced to 15% for offshore Divs. 3LNO in 2009-10.

VESSEL MONITORING SYSTEM (VMS) AND DOCKSIDE MONITORING PROGRAM (DMP) 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, Newfoundland Region of DFO. 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.

VMS-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 (e.g. 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 (Divs. 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 1994-2014. 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 late August to mid-September and occupies five of the inshore fall multi-species survey strata (Fig. 7) with set locations randomly distributed within each stratum, and stratum-specific set allocations weighted by area. Each set includes six traps, with crabs sampled from three large-meshed (commercial, 135 mm) and three 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 (1979-2013) within Div. 3L (Bonavista and Conception Bays) and a trap survey within Subdiv. 3Ps (Fortune Bay, 2007-13) (Fig. 7). 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 commercial (135 mm) and small-meshed (27 mm) traps in each set. 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 recorded. 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. A new vessel was commissioned to conduct these inshore trawl surveys in 2012. As it was deemed to have a different catchability than the previous vessel, the most recent survey indices are not comparable to historical data. With an insufficient time series of data established using the new vessel, these trawl survey data were omitted from this assessment.

COLLABORATIVE POST-SEASON TRAP SURVEY

Data were examined from industry-DFO Collaborative Post-Season (CPS) trap surveys in Divs. 2J3KLOPs4R (Fig. 8). 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 1 September each year. The surveys, conducted by Snow Crab harvesters accompanied by at-sea observers, focus on commercial (i.e. 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. 8). At each station, six (inshore) or ten (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. 8) 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 of 2010 (Mullowney et al. 2012a) (Fig. 8). The depth-based stratification scheme closely conforms with 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), analagous 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 are biased in that chela height 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 conditions of 76-94 mm CW males from this survey was introduced in the previous assessment and was used to infer 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

BROAD-SCALE TRENDS: DIVISIONS 2HJ3KLNOPS4R

Fishery

The fishery began in Trinity Bay (CMA 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 Divs. 3KL (Fig. 1) 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 license 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 and fishery scales have increased in all 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 divisions.

Licenses supplemental to those of groundfish 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 licenses in 2003 and exploratory licences in the offshore were converted to full-time licenses in 2008. There are now several fleet sectors and about 2,700 license holders in the fishery, with several rationalization initiatives gradually reducing the number of active licenses in recent years. In the late 1980s, 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 (Divs. 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 are commonplace.

Historically, most of the landings have been from Divs. 3KLNO. Landings for Divs. 2HJ3KLNOP4R (Table 1, Fig. 9) have remained at 50,000-53,000 t since 2007. However, Divs. 3LNO has accounted for a steadily increasing percentage in recent years, from about half in 2009 to 70% in 2014.

Effort, as indicated by estimated trap hauls, approximately tripled throughout the 1990s as the fishery grew (Dawe et al. 2004). Spatially, the distribution pattern has since remained broad-based, with only slight annual changes in recent years (Fig. 10). In the north, effort in Div. 2H and the northernmost portion of Div. 2J has gradually dissipated since 2011, with Div. 2H virtually abandoned in 2014. In Div. 3K, effort greatly expanded in 2009 and has been relatively intense in deep areas of the division since, although it was reduced in the outermost areas of the offshore in 2014. Effort in Divs. 3LNO has been relatively fixed in distribution since 2009, while in Subdiv. 3Ps, expansion in spatial coverage of the fishery has occurred in the southernmost portion of the area in recent years. In Div. 4R, effort had become increasingly contracted and highly aggregated throughout the 2000s, but the fishery has grown in recent years with heavier concentrations of effort occurring inside the restricted confines of the inshore management areas as well as in localized aggregations throughout the offshore since 2010.

The timing of the fishery has differed both across and within divisions in recent years (Fig 11). Generally, the fishery in all divisions has occurred earlier since 2010, the shortest seasons have occurred in Div. 4R off the west coast where spring ice conditions are generally light and biomass and quotas relatively low, and the longest seasons have occurred in Divs. 3LNO where the biomass and quotas are highest.

A delay occurred in opening the northernmost Divs. 2HJ fishery in 2014 due to heavy ice conditions. The fishery began in the early part of June (i.e. Week 9), about 4-5 weeks after the normal opening date of early May that occurred during 2010-13 (Fig. 11). Nonetheless, the pace of the 2015 fishery was relatively quick and the majority of crab was taken by mid-late July (i.e. Week 16), similar to previous years. The opening of the fishery in Div. 3K, both inshore and offshore, was also delayed in 2015 due to ice. The fishery got underway with appreciable effort in mid-May (i.e. Week 6), about three weeks behind that of previous years. In the offshore, there was little difference in end dates compared to 2011-13, with the majority of the crab landed by early-mid July (i.e. Week 14). Although the majority of the crab was landed by about the same time in the inshore, the season was prolonged compared to the near-completion dates of weeks 11-12 that occurred in the previous three years. There were no delays in opening or finishing the Divs. 3LNO or Subdiv. 3Ps fisheries in 2014. Similar to the previous three years, these fisheries began near the beginning of April (i.e. week 1) and the majority of the crab was landed by about mid-July (i.e. Week 14-16) although the Subdiv. 3Ps inshore fishery finished up earlier, during early-July (i.e. Week 12). In Div. 4R, the 2014 fisheries began about mid-April (i.e. Week 2) and the majority of the crab was landed by about mid-June (i.e. Week 10) in both the inshore and offshore.

Logbook CPUE has been relatively low in all areas except Divs. 3LNO since 2012 (Fig. 12). Considerable changes occurred from 2009-12. In 2009, catch rates were highest off the south coast of the Province in Divs. 3LOPs, and far offshore areas of Div. 3K were experiencing relatively high catch rates. However, by 2012 catch rates had declined in most of these areas, although Subdiv. 3Ps inshore remained strong along with some isolated pockets in Div. 3O, while they had increased markedly in peripheral areas of the Grand Bank in Divs. 3LN. In 2014, catch rates in all areas except the perimeter of the Grand Bank in Divs. 3LN were generally below 10 kg/trap, and especially low (i.e. below 5 kg/trap) off the west and south coasts in Divs. 4R and Subdiv. 3Ps and in some inshore areas of Div. 3K along the northeast coast. Overall, the spatial distribution of fishery CPUE suggests the resource has recently become increasingly concentrated into Div. 3L along the northern portion of the Grand Bank, where catch rates have been very high in the past three years. The Div. 3N slope, where catch rates had been very high in 2012-13, showed noticeable signs of declining catch rates in 2014.

Logbook CPUE has shown a great deal of variability both across and within divisions over the past twenty years (Fig. 13). Most recently, in northernmost Div. 2J it has been relatively high during the past two years. Other areas experiencing catch rates near or above average in recent years include Divs. 3LNO offshore and 3L inshore, as well Div. 4R offshore and inshore. Conversely, Div. 3K offshore and inshore, as well as Subdiv. 3Ps offshore and inshore, all experienced decreases in CPUE in the past few years and are at or near their lowest observed levels. In all but Div. 4R offshore and inshore a negative relationship between CPUE and area fished has occurred since 1995. This is thought to reflect the level of searching necessary to capture the TAC in any given year and division, with little need to search for alternate fishing grounds when traditional areas yield high catch rates. The situation differs in Div. 4R offshore and inshore where stock biomass has traditionally been low and the positive relationship is deemed to reflect a fishery of opportunity, with effort expanding in spatial scale when crabs are abundant and catch rates high. Div. 2J experienced its lowest spatial coverage by the fishery in 2014, while 3Ps offshore was near its highest level. With > 60% of the grounds receiving fishing effort, Div. 3L inshore is the most intensively fished area by this index. The declining trend in spatial coverage in the Div. 3K offshore fishery while catch rates have been low in recent years reflects abandonment of poorly performing fishing grounds.

Similar to logbook CPUE, at-sea observer sampling from the offshore has shown a spatio-temporal shift in catch rates in recent years. In the north, Div. 2J experienced a recent high period from about 2006-09 and lower CPUE since, with the exception of an anomalously high 2013 value from the research sampling data (Fig. 14). In Div. 3K, CPUE doubled from about 9 kg/trap in 2005 to 18 kg/trap in 2008, but has since returned to the 9 kg/trap level. In Divs. 3LNO, a prolonged gradual decline in catch rates occurred during 2003-08, which has since been countered by a prolonged gradual increase, with CPUE hovering about 18 kg/trap during the past three years. In Subdiv. 3Ps, catch rates gradually increased from 2005 to a recent high in 2009-10, but have since steadily declined to a historic low of about 6 kg/trap in 2014. Overall, the picture suggests, as with logbook CPUE, a concentration of the resource into Divs. 3LNO in recent years, where the fishery has performed very well. Particular concerns arise in Div. 3K and Subdiv. 3Ps offshore where observed catch rates were at or near their lowest observed levels in 2014.

Biomass

Logbook catch rates have shown positive associations with survey exploitable biomass indices in three of the four major offshore assessment divisions. Scatterplots reveal a general asymptotic distribution, with strongest relationships occurring both within year and at a one year lag. Linear or logarithmic model fits range from about r^2=0.65-0.73 in most cases (Fig. 15). The division with poor agreement, 3LNO, has been characterized by suspect trawl performance in some recent years, with the fall survey exploitable biomass index deemed less reliable than fishery and trap survey indices in reflecting resource status (Mullowney et al. 2014b). The agreement of indices both within year and at a one year lag in most divisions likely reflects a situation whereby the exploitable biomass in any given year affects the fishery of both the present and succeeding year. The small spatial scale of most of the management areas (Fig. 2), whereby harvesters have limited room to search the grounds, could contribute to the reliability of fishery CPUE in reflecting exploitable biomass. Whatever the reason, the general overall agreement of the fishery dependent and independent data suggest CPUE appears to reflect exploitable biomass fairly well for this resource (Fig. 16).

Resource surveys indicate that in Divs. 2HJ, the exploitable biomass, as reflected by the post-season trawl survey index, has increased from its recent low in 2011 (Fig. 17). The post-season trap survey index also increased in 2014, but this index is considered less reliable than the trawl survey index because of limited spatial coverage. In Div. 3K offshore, the exploitable biomass, as reflected by the post-season trawl and trap indices, has declined steadily since 2008 to be at or near its lowest level. In Divs. 3LNO, the indices of exploitable biomass from post-season trap and trawl surveys diverged during 2009 to 2011 with the trap index increasing and the trawl index declining. It is believed that the trend in the trap survey index better reflects the trend in the exploitable biomass because it is supported by the increasing fishery performance during that time (Fig. 16). The indices of exploitable biomass from spring and fall trawl and trap surveys decreased, to differing degrees, in 2014. Although the fall trawl survey was incomplete in 2014, it showed a decrease in the exploitable biomass index in Div. 3L (not shown), indicating the sharp decrease in 2014 was not fully attributable to the omission of Divs. 3NO from the survey. In Subdiv. 3Ps, the exploitable biomass, as indicated by the spring trawl and fall trap survey indices, has been at its lowest level during the past two years.

Although biomass levels have changed considerably across divisions in recent years, with general reductions in most divisions opposed by increases in Divs. 3LNO, the spatial distribution of exploitable male concentrations within each division has remained relatively consistent, reflecting the pattern described by Dawe and Colbourne (2002). Large exploitable males are generally concentrated in deep areas of each division (Fig. 18-19), reflecting an ontogenetic movement toward these areas over the course of life. Division-specific spatial distributions are examined in finer detail in forthcoming sections of the document.

For the stock as a whole, multi-species trawl surveys indicate that the exploitable biomass was highest at the start of the survey series (1995-98, Fig. 20). It declined from the late 1990s to 2003 and then increased to about 2009. The overall exploitable biomass has recently declined, and both the trap and trawl surveys indicate that Divs. 3LNO has accounted for a steadily increasing percentage in recent years and now accounts for most of the biomass. In 2008, Divs. 3LNO accounted for about 40% of the exploitable biomass index from the CPS trap survey and by 2014 that percentage has doubled to about 80%.

Recruitment

Overall, recruitment has declined in recent years and is expected to decline further in the short term (2-3 years). Trap and trawl survey biomass indices of pre-recruits (Fig. 20) increased from 2006-07 to 2009-10 due to increases in the South (Divs. 3LNOPs). Both the trap and trawl surveys indicate that Divs. 3LNO has accounted for an increased percentage in recent years, with about 70-75% of the pre-recruit index from the trap survey occurring in those divisions. Of particular concern is that the recently decreasing trend in all three indices from spring trawl and fall trap and trawl surveys is being driven by Divs. 3LNO, where the bulk of the biomass and landings occur. The increasing percentage of old-shell crabs in the trap-based index warrants further concerns. This index is only sized-based and does not differentiate between adults and adolescents due to chelae not being measured during the survey. Old-shelled crabs are deemed to have a higher probability of being terminally molted, thus the increasing percentage of old-shelled crabs in the index infers the actual rate of decline in pre-recruit biomass is higher than depicted by the face-value rate of decline in the index.

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. The proportion of new-shelled crabs in the exploitable biomass is used as an index of the relative strength of recruitment into the biomass each year, and the associated level of the fisheries reliance upon immediate recruitment. As a general rule, the fishery has become increasingly reliant upon immediate recruitment everywhere, with decreasing proportions of old-shelled crabs in the exploitable population since the late-1990s and early-2000s in all divisions (Fig. 21). This infers higher levels of exploitation by the recent fisheries relative to earlier years, with fewer crabs now surviving to oldest post terminal-molt ages.

Divs. 2HJ is particularly reliant upon recruitment each year, with the majority of the exploitable biomass comprised of new-shelled crabs since the early-2000s (Fig. 21). The increase in the exploitable biomass index in 2014 was almost wholly attributable to an increase in new-shelled crabs, with intermediate- and old-shelled crabs (constituting the residual biomass) remaining a minor portion of the population both in the trawl (Fig. 21) and trap (Fig. 22) survey indices. The recent decline in exploitable biomass in Div. 3K largely reflects a decline in recruitment, as there has been relatively minor change in shell-condition specific contributions over time with new-shelled crabs comprising 40-70% of the biomass each year since 1998 (Fig. 21). This is consistent with the trap survey index which shows roughly equal proportions of new- and older-shelled crabs comprising the exploitable biomass each year since 2008 (Fig. 22). The biomass index of recently-recruited crabs in Div. 3K offshore has remained near its lowest observed level for six consecutive years in both surveys. In contrast, the trap survey suggests the level of recruitment into the exploitable biomass in Div. 3K inshore has been relatively consistent for the past decade, while a gradual decrease in the old-shelled residual component has occurred since 2006 (Fig. 22).

Divs. 3LNO also relies heavily on recruitment each year, particularly in the recent period, with 55-70% of exploitable crabs in the fall trawl survey index being new-shelled since 2008 (Fig. 21). Similarly, the trap survey shows about half the crabs in the exploitable biomass have been new-shelled in most years since 2007, although the index diverged in 2014 with older-shelled crabs dominating (Fig. 22). In Div. 3L inshore, a gradual decrease has occurred in the index of new-shelled crabs into the exploitable biomass since 2010, while the old-shelled residual component has grown to its highest level in the time series in the past three years. Chronologically, the growth of new-shelled recruits in the offshore exploitable biomass, as well as the residual component of the biomass index in both the inshore and offshore, reflects the build-up of pre-recruit crabs from about 2007-10 (Fig. 20). The declining pre-recruit signal coupled with declining recruitment into the exploitable biomass in 2014 is a point of concern, suggesting a decline in recruitment prospects which has been anticipated for a few years in these divisions (Mullowney et al. 2014ab) may be starting to come to fruition. Nonetheless, at present the overall exploitable biomass in these divisions is relatively strong. The consistently high level of soft-shell crabs in the Divs. 3LNO spring trawl survey may reflect the greater productivity of this area relative to other divisions. Although years of low soft-shell biomass have occurred in the past, the virtual absence of soft-shell crabs in the last two years coupled with the dwindling signals of pre-recruit biomass (Fig. 20), suggests reduced recruitment into the exploitable biomass is imminent in this division and consequently for the stock as a whole in the near future.

Like all other areas, Subdiv. 3Ps relies heavily on recruitment, with about 40-60% of the spring exploitable biomass index comprised of new-shelled crabs each year since 2000 (Fig. 21). This is consistent with the trap survey index in both the offshore and inshore (Fig. 22), although the inshore area has been dominated by old-shelled crabs in the past two years. Overall, both the trawl and trap survey biomass indices from Subdiv. 3Ps show that the most recent rise in exploitable biomass from 2007-09, and the subsequent decline, reflect a consistent trend in all shell components. Both recruitment and residual components of the exploitable biomass have declined throughout Subdiv. 3Ps in recent years and all indices are indicating the exploitable biomass is at or near its lowest observed level. Trawl survey biomass indices from Div. 4R offshore are deemed unreliable for assessment and the trap survey index from Div. 4R offshore was incomplete in 2014. The exploitable biomass in Div. 4R offshore is deemed very low, with both surveys only sporadically catching crabs. In inshore Div. 4R, the trap survey index showed the exploitable biomass had been almost wholly comprised of new-shelled crabs from 2010-12. However, the signal of new-shelled crabs has since become greatly reduced, almost 0 kg/trap in 2014, with old-shelled crabs now dominating the overall declining exploitable biomass (Fig. 22).

Survey biomass indices of pre-recruits have recently declined in all areas except Divs. 2HJ (Fig. 23), and short-term (2-3 year) prospects are either uncertain or poor in all offshore divisions. In Divs. 2HJ, short-term recruitment prospects are uncertain due to variability in the pre-recruit biomass indices from both surveys. In Div. 3K, recruitment is expected to remain low in the short-term as both the post-season trawl and trap survey pre-recruit biomass indices have declined since 2008 to their lowest levels. In Divs. 3LNO, recruitment is expected to decline in the short-term as the pre-recruit biomass indices from spring and fall trawl and trap surveys have all declined since 2010. Finally, in Subdiv. 3Ps, recruitment is expected to remain low in the short-term as pre-recruit biomass indices from both trap and trawl surveys declined rapidly from 2009 to their lowest levels in 2013-14 (Fig. 23).

Akin to exploitable crabs, although biomass levels of pre-recruits have changed considerably across divisions in recent years, the spatial distribution of exploitable male concentrations within each division has remained consistent. Their distribution is similar to that of exploitable males, with crabs generally concentrated in deep areas of each division (Figs. 24-25) where they appear to aggregate following ontogenetic movements from shallower areas earlier in life. Again, division-specific distribution patterns are examined in forthcoming sections of the document.

Despite poor short-term recruitment prospects for most divisions, the emergence of a pulse of small crabs in the past three years suggests a modest increase in recruitment for some divisions in about six to eight years. This pulse of small crabs can be seen by an increase in the Divs. 2HJ3KL fall abundance index of < 40 mm CW crabs in the past two years, to a level not seen since the early 2000s (Fig. 26). The pulse of small crabs observed in the early 2000s is what is likely fueling the present high fishery catch rates and exploitable biomass in Divs. 3LNO, and the same pseudo-cohort of crabs that has recently progressed through pre-recruit sizes in most other divisions. Further strengthening the hopes for some increased recruitment in the long-term is an extremely high abundance index of small crabs in the Divs. 3LNOPs spring surveys, which despite high variability and uncertainty about the 2014 point estimate, appears consistent with recent fall survey results in showing a marked increase.

This present emergent pulse of small crabs can be seen in size frequency distributions from both the fall (Fig. 27) and spring (Fig. 28) trawl surveys with relatively high abundance of both sexes, particularly in 2014. The size frequency distributions depict a resource which has experienced three pulses of high productivity since surveys began; one during the mid-1990s, one during the early-2000s, and the present one. With low levels of productivity occurring from about 2004-13, relative to previous levels of exploitable biomass and that currently being experienced in Divs. 3LNO, at the stock level the prognosis for short- and mid-term fishery prospects is unfavourable (Mullowney et al. 2014a). The dissipation of pre-recruit crabs in recent years is especially evident in the fall survey series, with decreasing levels of adolescent crabs greater than 75 mm CW captured in the surveys since 2008 (Fig. 27).

The spatial distribution of small crabs in the surveys differs from that of larger pre-recruit and exploitable-sized males. Generally, they are captured in shallower areas (Figs. 29-30) where cold conditions (Fig. 5) are thought to promote early-life survival.

Reproduction

The management regime of the NL, and virtually all other commercially harvested Snow Crab stocks, inherently protects the reproductive potential of populations by restricting all females and a large proportion of breeding males from exploitation. The fishery targets only the largest males, which constitutes a small fraction of the overall resource. Although this could theoretically have implications for genetic selection, the strategy of maintaining a residual biomass of largest males, coupled with the ability of sub-legal-sized adolescent and adult males to successfully copulate and breed, appears to be successful in maintaining reproductive potential in this stock. Reproductive potential is further safeguarded by the ability of mature females to store sperm and produce multiple clutches of eggs from a single mating event (Sainte-Marie 1993).

The inherent reproductive resiliency is evident in the index of egg clutches of females from the multi-species trawl surveys. Data from both the fall and spring surveys throughout Divs. 2HJ3KLNOPs show that in nearly all years the vast majority (i.e. >80%) of mature females in all divisions are carrying full clutches of viable eggs (Fig. 31). Fluctuations that have occurred in the exploitable biomass appear to have exerted little impact on mating success for females, at least to date. A few notable exceptions have occurred, such as low percentages of clutch fullness in Divs. 2HJ in 1999, 2006, and 2007, in Divs. 3LNO and Subdiv. 3Ps spring surveys in the mid-2000s, and in two of the last three years in the Divs. 3LNO fall survey (excepting the incomplete 2014 value). Nonetheless, the overall reproductive potential appears to have been maintained each year under the current management regime.

This index of egg clutches may best form the cornerstone to defining 'serious harm' to the Snow Crab resource caused by fishing. With no prolonged periods of low clutch fullness, the evidence suggests that under current management practices the species maintains a high level of resiliency to fishing, with all levels of exploitable biomass observed to date causing no serious harm to the reproductive potential of the stock. Current prevailing theory is that productivity and recruitment success is driven more by bottom-up climatic and inter-specific competition factors than top-down fishery or predation impacts (Windle et al. 2012; Dawe et al. 2012b; Mullowney et al. 2014a). The scenario of low potential for serious harm induced by fishing and productivity being predominately environmentally-driven suggests conventional exploitation rate-based Precautionary Approach (PA) frameworks (i.e. DFO 2014) may be inappropriate for this stock. At present, alternative PA frameworks are being pursued for this resource.

Following an initial high period in the late 1990s, the abundance of mature females has remained relatively low and highly annually variable in all divisions (Fig. 31). Such 'cyclic' pulses have been described in other areas, including the northern Gulf of St. Lawrence (i.e. Sainte-Marie 1993; Sainte-Marie et al. 1995). It is unknown what effect over production present levels will have in any given division. Historically, largest recruitment pulses have been born from periods of low mature female abundance. For example, the 20-30 mm crabs seen in the 2001-02 surveys (Fig. 27) would be expected to be about 2-3 years of age (Sainte-Marie et al. 1995) and been produced from the relatively low levels of abundance of mature females that occurred in 1998-2000, and the present pulse of small crabs of about the same size would have been produced from the low mature female abundance levels seen during recent years (i.e. 2011-12).

Although poorly captured by the multi-species trawl surveys, the observed shallow water pattern of distribution of mature females (Figs. 32-33) appears to more closely mirror that of small males than pre-recruit and/or exploitable crabs. Like all other population components, division-specific distributions are examined in finer detail in forthcoming sections of the document.

Environment

Knowledge on the impacts of bottom temperature on Snow Crab population dynamics has recently advanced. It is becoming increasingly apparent that bottom temperatures act positively on size and negatively on abundance in regulating stock biomass. 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 (Dawe et al. 2008; Marcello et al. 2012) than it is on the negative effects of a cold regime on size-at-terminal molt. Cold conditions early in the life history are associated with the production of strong year classes and subsequent strong recruitment (Boudreau et al. 2011; Marcello et al. 2012; Mullowney et al. 2014a; Émond et al. 2015).

The impact of cold water on early-life survival is evident by the consistency of lagged correlations between bottom temperatures, represented by division-specific habitat indices of areal expanse of cold water, and future fishery CPUE across divisions along the Newfoundland and Labrador shelf (Fig. 34). The best fits of these correlations occur at lags of seven years in Divs. 2HJ and Subdiv. 3Ps, at eight years in Div. 3K, and at nine years in Divs. 3LNO. The cross correlations were significant at $p=0.0001$ in Div. 2J, $p=0.0353$ in Div. 3K, $p=0.0017$ in Divs. 3LNO, and $p<0.0001$ in Subdiv. 3Ps (not shown). However, despite this, it is believed that year over year changes in temperature do not directly correspond to year-specific catch rates. Rather, the analysis is best viewed as a periodic phenomenon, with auto-correlation occurring in both variables.

The longest lag in coldest Divs. 3LNO is thought to reflect a higher incidence of skip-molting for crabs in that area. Previous assessments have shown such correlations to occur with the shorter time-series of exploitable biomass from the trawl surveys (i.e. Mullowney et al. 2012a; 2013). Generally, with the exception of divergence with an unusually high CPUE in Div. 3K in 2007-08, the predictive capacity of these thermal indices for future fishery success has been high. In all divisions the underlying trend in habitat indices has been oscillating downward. Fishery CPUE indices have generally followed this pattern to date, but improved management practices promoting shortened seasons and reduced wastage in most areas of the fishery may presently be, or could potentially, help maximize more of the resource potential in the future and offset what appears to be a less productive regime in the foreseeable future.

Recent and on-going work has linked the abundance of small crabs in the trawl surveys with bottom temperatures occurring in real time in Newfoundland and Labrador (unpublished data), more directly addressing the impact of bottom temperatures on early-life survival. In other regions such as the Southern Gulf of St. Lawrence, Eastern Bering Sea, and Northern Gulf of St. Lawrence (Marcello et al. 2012; Émond et al. 2015) climate data have been directly linked to survey-based indices of small crab abundance. The present emergence of a pulse of small crabs (Figs. 27-28) has been associated with cooling oceanographic conditions in the past three years (Fig. 35).

Although a return to cooler conditions in the past three years is positive in that it appears to have promoted the emergence of a pulse of small crabs, expectations for the future should be tempered as climatic conditions are still relatively warm (i.e. Colbourne et al. 2013). The ocean climate indices have varied considerably over the past decade, introducing uncertainty beyond the short-term, but the overall trend is warming, with record warm conditions in 2011. Present cold bottom conditions are not near as spatially or temporally expansive as they were in the late-1980s and early-1900s (Fig. 35), from which highest exploitable biomass levels in the mid-late-1990s likely originated (Fig. 20) (Mullowney et al. 2014a). Nonetheless, cross-correlation analyses in Divs. 3LNO would suggest that the present high level of fishery catch rates in that division are associated with the pulse of cold water that occurred from about 2000-03, and current thermal conditions are approaching that level. Long-term abundance may heavily hinge on the extent to which the current cold conditions are sustained, although it is unknown how environmental, anthropogenic, or other factors will interfere with the survival and progression of this emergent and future recruitment pulses throughout life.

The pulse of cold water that occurred from about 2007-09, most prominently in Divs. 3LNO and Subdiv. 3Ps, appears to be largely unaccounted for with respect to the presence of small crabs in the trawl surveys (Figs. 27-28), with only a weak suggestion of any increase in abundance of small crabs (i.e. 12-30 mm CW) in both surveys during 2010-11. Further, small-mesh traps from the CPS survey in Div. 3K offshore show no clear indication of any emergent recruitment pulse from that period (Fig. 36). However, in Divs. 3LNO (Fig. 37) and Subdiv. 3Ps (Fig. 38), a recent pulse of mid-sized crabs has begun to be tracked in the CPS survey small-mesh traps. The pulse originally appeared in 2012, centered at modal groups of about 38 mm and 32 mm CW in Divs. 3LNO and Subdiv. 3Ps, respectively. The modes have since progressed to be centered at about 56 mm CW and 50 mm CW in the two divisions. Crabs of this size would likely be about five or six years of age (Sainte-Marie et al. 1995), thus they would have most likely been born during the late 2000s. That there is no evidence of a recruitment pulse of crabs of similar size emerging from the late 2000s in Div. 2J or Div. 3K is consistent with a less pronounced period of cold water in those divisions at that time.

Chronologically, for the previous pulse of recruitment detected in the trawl surveys as 12-30 mm CW crabs from about 2001-03 (Figs. 27-28), the CPS survey small-mesh traps began detecting and tracking the crabs at about 35-41 mm CW in Divs. 3LNO in 2005 and at about 50 mm CW in Subdiv. 3Ps in 2006 (Figs. 37-38). Although the scenario appears very similar with the present pulse, there is an important fundamental difference to consider in tempering expectations from the currently approaching signal. The earlier pulse was more spatially broad-based than the current one. The small mesh traps yielding the present positive recruitment potential signals are localized to the Whale Deep, Green Bank, and St. Pierre Bank Areas (Fig. 4), whereas the previous pulse occurred across more of the Grand Bank, including the spatially expansive management areas of the northern Grand Bank in Div. 3L (Stansbury et al. 2014). Accordingly, it may not be reasonable to expect this approaching recruitment pulse to yield as much biomass to the broader-scale fishery. It will be imperative to monitor the spatial extent to which these crabs disperse and/or increase the pre-recruit biomass indices in these divisions in the next few years to better determine the extent to which they may contribute to the success of mid-term fisheries in these divisions.

Mortality

Bitter Crab Disease has been observed, based on macroscopic observations of crabs captured in the fall trawl surveys, at generally low levels throughout 1996-2014 (Fig. 39). The prevalence and distribution of this parasitic disease throughout the Newfoundland and Labrador Shelf has been described in detail by Dawe (2002) and appears related to circulation features (Dawe et al. 2010b) and the density of small crabs (Mullowney et al. 2011).

The disease, which is fatal to crabs, occurs primarily in new-shelled crab of both sexes and appears to be acquired during molting (Dawe 2002). Although the macroscopic analyses used to classify crabs as infected are known to underestimate true prevalence, a recent study using advanced polymerase chain reaction (PCR) techniques on specimens collected since the mid-2000s to identify infections has shown trends to closely reflect the patterns seen throughout the offshore (unpublished data). BCD has been consistently low in fall trawl surveys in Div. 2J and although it is normally most prevalent in Div. 3K, levels in that division have been lower since 2000 than previously occurred. BCD is normally not common in Divs. 3LNO, but a prolonged pulse was observed in Div. 3L from about 2001-06, most prominent in 40-59 mm CW crabs, that peaked in 2004-05. This likely reflected progression of the recruitment pulse detected in the trawl surveys as 20-30 mm CW crabs in 2000-03, and presently contributing to high fishery catch rates in that division, through those sizes.

Overall, the relatively low levels of BCD observed in recent years is positive in that it suggests this source of natural mortality is killing fewer crabs than historically. However, it is also negative in that it suggests a decreased density or abundance of mid-sized crabs, representing future fishery prospects, presently occurring along the major areas of the NL shelf. Spatially, the disease has tended to follow a pattern of being most prominent in shallow nearshore areas of the continental shelf with a virtual absence in deeper areas further offshore (Fig. 40). At present, BCD is not thought to be exerting much of a regulatory effect on Newfoundland and Labrador Snow Crab populations but its importance could once again increase as the newly emergent recruitment pulses grow into sizes more commonly associated with the disease over the next few years.

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-shell) Snow Crab are subject to more damage and mortality than hard-shelled crab (Miller 1977, Dufour et al. 1997).

Prevalence of soft-shell legal-sized males in the catch is a function of both fishery timing and exploitable biomass level. Mortality on soft-shelled males can be minimized by fishing before soft-shell crabs are capable of climbing into traps and further reduced by maintaining a relatively high exploitable biomass level. When catch rates of large hard-shelled crabs are maintained at a high level soft-shell crab encounters in the fishery are consistently low, likely reflecting the inferior competitive ability of soft-shelled animals.

The soft-shell protocol was introduced in 2005 to protect immediate pre-recruits from handling mortality by closing localized areas (70 sq. nm grids) for the remainder of the season when a threshold level of 20% soft-shell (now 15% in Divs. 3LNO) in 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 approach of assuming unobserved grids had no problem. In addition, failure to draw inferences from samples smaller than the minimum required (250 per grid per week) has frequently resulted in failure to invoke the protocol even when it is obvious that the level of soft-shell crabs has exceeded the threshold. These shortcomings undermine the intent of the protocol. Further, when soft-shell crab is widespread, grid closures may result in concentration of fishing effort in other areas with high but unobserved prevalence. Measures should be taken to ensure representative observer coverage and analysis so as to better quantify prevalence of soft-shell crabs, and consequently fisheries-induced mortality.

Trends in fishery-induced mortality, both on exploitable and pre-recruit crabs, have varied among divisions throughout the time series. In Divs. 2HJ, the pre-recruit fishing mortality index has increased over the past ten years to above the median level while the exploitation rate index increased steadily from 2007-12, but decreased to a moderate level in the past two years (Fig. 41). Maintaining the current level of fishery removals would further reduce the exploitation rate in 2015. In Div. 3K, the pre-recruit fishing mortality index has varied at a moderate level since 2009 while the exploitation rate index increased from 2008-10 and has since changed little. Maintaining the current level of fishery removals would result in a continued high exploitation rate in 2015. In Divs. 3LNO, the exploitation rate index has changed little over the last four years and the pre-recruit fishing mortality index has remained relatively low since 2008. Maintaining the current level of fishery removals would likely increase the exploitation rate in 2015. In Subdiv. 3Ps, the exploitation rate index has been at or near its highest level during the past two years and the pre-recruit fishing mortality index has increased steadily since 2010 to its highest level in 2014. Maintaining the current level of fishery removals would result in a continued high exploitation rate in 2015.

Rates of mortality imposed by discarding are unknown, but a recent study conducted and presented for peer review at this stock assessment showed that about 30% of even the hardiest crabs (not soft-shell) were either directly killed or rendered critically weak from being discarded (unpublished data). However, the analysis was biased by the re-hauling of crabs in the experiment which could have inflated mortality rates, and did not feature soft-shell samples in the analysis. Mortality rates on soft-shell crabs are thought to be especially high.

Discard rates have been negatively related to ratios of exploitable to pre-recruit biomass indices from the trawl surveys in all divisions throughout the time series (Fig. 42). Although top-down mortality effects from fishing likely influence the relationships, with the potential of mortality imposed by discarding predominately imposed on pre-recruits and skewing the ratios toward exploitable crabs, the consistent negative relationships likely reflect the relative level of both groups of crabs and discard percentages are likely to increase when pre-recruit levels are relatively high. In this regard, the fishery becomes wasteful and most inefficient when pre-recruitment potential is high and least wasteful and most efficient when pre-recruitment potential is low. The higher the ratio of exploitable to pre-recruit crabs, the higher the likelihood that the fishery can be prosecuted with minimal damage to incoming pre-recruits.

Discarding has overall been consistently lowest in Divs. 3LNO (Fig. 42), and generally been less of concern in the other three major divisions since the mid-2000s than prior. In Div. 2J, a high incidence of discarding and a low exploitable:pre-recruit ratio period in 2002-04 was associated with high catch rates of legal-sized soft-shell crabs (i.e. immediate pre-recruits) in the fishery (Fig. 43) and extremely high levels of pre-recruit mortality (Fig. 41). This pattern has somewhat repeated itself in recent years, when catch rates of legal-sized soft-shell crabs have again been relatively high. However, the more controlled levels in the exploitable:pre-recruit ratio and pre-recruit fishing mortality rate index in recent years infer the fishery has been more efficient during this period of incoming recruitment. Further, the modestly increasing trend in the exploitable:pre-recruit ratio in the past two years suggests reduced potential for wastage in the 2015 fishery. Such improved efficiencies in yield-per-recruit are likely to be beneficial for future harvests under the scenario of expected declines in recruitment in the short-and mid-terms in most areas.

In Div. 3K, compared to historical norms, relatively few legal-sized soft-shell crabs have been captured in the fishery since 2005, with observed lows in the past two years (Fig. 43). This signifies increasingly poor short-term recruitment prospects, but the relatively high and increasing trend in the exploitable:pre-recruit ratio (Fig. 42) also indicates a decreasing level of potential for damage to the incoming recruits. The persistence of a relatively low-level in the pre-recruit fishing mortality index since 2004 (Fig. 40) suggests that the prolonged decline in the exploitable biomass and fishery catch rates (Fig. 16) experienced since the late 2000s has overall been more a function of low recruitment than fishery wastage or inefficiency, at least in most years.

In Divs. 3LNO, there has been a virtual absence of soft-shell and under-sized new-shell crabs in the fishery in the past two years, signifying the lowest short-term recruitment prospects observed to date (Fig. 43). The extremely high exploitable:pre-recruit ratio indicates very low potential for damage to incoming recruits and wastage in the fishery in 2015, associated with a level of fishing that already appears efficient and effective in avoiding pre-recruit wastage, as the pre-recruit fishing mortality index has remained relatively consistent since 2008 (Fig. 41).

In Subdiv. 3Ps, there have been few soft-shell crabs captured in the fishery since 2005, with a steadily declining signal of under-sized new-shell crabs in the catch (Fig. 43). The relatively high levels of the pre-recruit fishing mortality index in the most recent years (Fig. 41), coupled with an increasing trend in the ratio of exploitable:pre-recruits (Fig. 42), indicates that the rate of decline in pre-recruits has been higher than that of exploitable crabs in recent years. This does not appear attributable to handling mortality, with virtually no soft-shell crabs seen in the fishery for nine consecutive years (Fig. 43). Observer discard data suggest Subdiv. 3Ps has experienced a prolonged period of steadily declining recruitment into the exploitable biomass.

DIVISIONS 2HJ OFFSHORE

Fishery

The Divs. 2HJ fishery occurs in offshore regions of central and southern Labrador in CMAs 1 and 2 (Fig. 44). 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 Div. 2J is longer, extending back into the early 1980s. Landings in Divs. 2HJ (Table 2, Fig. 45) were at their lowest level in two decades in 2013 but increased by 25% to 1,740 t in 2014. Meanwhile, effort has been at its lowest level in two decades during the last two years. The shortfalls in achieving the TAC in 2011-13, and the subsequent taking of the TAC in 2014, predominately reflect a poor performing and now improving fishery in the northernmost management area (CMA 1), dominated by removals from the Cartwright Channel.

Logbook return rates in Divs. 2HJ are persistently low relative to other divisions and uncertainties associated with calculating and interpreting catch rates indices are comparatively high, particularly in the present year. In 2014, less than half the logbooks from fishing trips were accounted for in the logbook dataset. Adding to uncertainty in assessing fishery performance in this division is that the CPUE index derived from this incomplete logbook dataset is deemed the most reliable because observer coverage is routinely low and VMS is not required to be used by all fishing fleets. In 2014, the logbook CPUE index changed little, the observer index decreased drastically, and the VMS index increased substantially (Table 2, Fig. 46). Given the uncertainties in all three indices, and with no clear agreement among them, the interpretation is that CPUE has increased since 2012 when all three indices were at or near a recent low.

Weekly CPUE trends are normally highest during the early portion of the season and tend to decline throughout the fishery (Fig. 47). This is interpreted as reflecting depletion of the resource. Despite a noticeable delay in beginning the 2014 fishery, the typical pattern of highest catch rates in the early season and reducing success thereafter occurred. The shortage of logbook returns in 2014 is evident in the index of CPUE measured against cumulative removals, with about 800 t accounted for in the cumulative catch index (Fig. 47) versus over 1,700 t of removals (Fig. 45). The late start, incomplete logbook dataset, and disagreement among catch rate indices render it difficult to judge the relative performance of the 2014 fishery.

Spatially, there has been a substantial reduction in the areal coverage of the fishery since 2011 (Fig. 48), a phenomenon often associated with a fishery that is performing well. The reduction of spatial coverage reflects a continued contraction of the fishery into the Cartwright and Hawke Channels in recent years. The northernmost fishing grounds of Div. 2H have been virtually abandoned and effort no longer extends into furthest offshore areas and the slope edge (Fig. 48). The reduction of effort in the northernmost areas likely reflects resource shortages, but could also be influenced by a regulation change after the 2012 fishery whereby vessels that had previously been restricted to Div. 2H were allowed access to the northern portion of the Cartwright Channel, inside Div. 2J at the southernmost portions of CMA 1. Since 2012, fishery catch rates have improved markedly in the Cartwright Channel and have been consistent or slightly improved in and around the Hawke Channel. The highest catch rates in 2014, in the range of 10-15 kg/trap, occurred along the Div. 3K boundary line in the southernmost portion of Div. 2J.

An area of Hawke Channel has been closed to all fisheries except Snow Crab from 2003 to 2012 ("Hawke Box" - Fig. 44). Logbooks indicate, as in most years prior to and following closure of the Hawke Box to bottom trawling and gillnetting, that there was no difference in CPUE inside versus outside the box in 2014 (Fig. 49). Mullowney et al. (2012b) found that the Hawke Box closure has done little to improve fishery productivity or catch rates because other fisheries do not represent a major source of mortality. Harvester reports suggest the poorly performing fisheries in the Cartwright Channel from 2011-13, where trawling occurs, were due to a high incidence of soft-shell crab and consequently the emergence of a recruitment pulse in that area in recent years.

Size distributions from at-sea sampling by observers during the fishery (Fig. 50) suggest there have been two recent recruitment pulses fuel the exploitable biomass during 2007-09 and 2012-14. This can be seen by an increase in abundance of soft- and new-shell legal-sized crabs during those periods. It is unclear if the most recent pulse has fully or near-fully contributed to the fishery, as there has been little evidence of modal progression of sizes in the population, and the magnitude of catch rates has fluctuated up and down in recent years with 2013 values being higher across the entire size range primarily due to elevated abundance of old-shell crabs in the observed population.

Improved harvester stewardship practices and management decisions in recent years appear to be benefitting the Divs. 2HJ fishery. Observer sampling throughout the season suggests that the recruitment pulse presently contributing to an improved exploitable biomass and fishery was allowed to enter legal-size with consistently reduced levels of potential perturbation and wastage from the fishery. For example, soft-shell crab incidence generally becomes most prominent in the latter weeks of the fishery here (Fig. 51). In recent years it first approached or exceeded the 20% grid closure threshold in week 9 in 2011, week 12 in 2012, week 14 in 2013, and week 16 in 2014. In comparison to effort expenditure, these weeks corresponded with about 50%, 70%, 90%, and 100% of effort expended in each season respectively (Fig. 47), thus the potential for fisheries-induced mortality on pre-recruits was reduced each year.

Surveys

Trawl and trap surveys both indicate that the exploitable biomass has increased since 2011 (Fig. 17, Table 3) due to increasing recruitment (Figs. 21-22). However, short-term (2-3 year) recruitment prospects are uncertain due to variability in the pre-recruit biomass index (Fig. 23, Table 3).

Size frequency distributions from both the trawl (Fig. 52) and trap (Fig. 53) surveys show increased levels of exploitable and pre-recruit crabs, particularly from 2013 to 2014. Mid-term recruitment prospects are uncertain in large part due to the persistently low signal of crabs in the survey trawl index ranging from poorly captured sizes of about 30-75 mm CW. However, in the past two years long-term recruitment prospects appear to have improved, with the abundance of crabs < 40 mm CW higher than it has been for about a decade (Fig. 52). If these crabs progress through sizes at rates similar to those historically seen, they would be expected to begin to contribute the fishery in about 2019-20.

Exploitable crabs in this division have been concentrated in the Cartwright and Hawke Channels (Fig. 54) with few captures by the survey trawl outside of these areas for the past six years. Notably, the survey trawl has captured no exploitable crabs in Div. 2H (i.e. North of 55 33N) in the past two years. Both main concentrations of exploitable crabs increased in magnitude in 2014. The distribution of pre-recruit crabs has been very similar to that of exploitable crabs. The low catch rates of pre-recruit crabs in the Hawke Channel in 2013 appears anomalous, and more frequent captures of pre-recruits occurred in both areas in 2014 (Fig. 55). Smallest crabs in the trawl survey have consistently been captured in shallower areas, on top of the Hamiltion Bank and adjacent nearshore plateaus, and their abundance has increased markedly both in terms of spatial distribution and magnitude of catches in the past two years (Fig. 56). Similar to small crabs, mature females tend to be most commonly captured at shallow depths on top of the Hamilton Bank and along the nearshore plateaus (Fig. 57). Catches tend to be sporadic, and with the exception of 2011 have appeared relatively consistent both in terms of frequency and magnitude since 2009.

The high degree of spatial overlap between small males and mature females, and the low degree of overlap between large males and mature females, suggests that either large movements must occur for breeding or that small males play a key role in the mating success of females in this area, or both.

DIVISION 3K OFFSHORE

Fishery

The Div. 3K offshore fishery occurs off the northeast coast of Newfoundland, predominately concentrated in the deep trenches of the Funk Island Deep and St. Anthony Basin which are situated between near-shore shallow plateaus and the Funk Island Bank (Fig. 58). The assessment unit incorporates CMAs 4, 3BC, and a portion of 3A (Fig. 58). Peak landings of about 18,000 t occurred in 1999, and with the exception of that anomalous year the highest total tonnage extracted has been about 13,000 to 14,000 t in a given year. Most recently, landings have declined by half since 2009 to 6,100 t in 2014, their lowest level in two decades (Fig. 59, Table 4). Meanwhile, effort has declined by a third. Commercial CPUE (Fig. 60, Table 4) indicates substantial deterioration of fishery performance in recent years. It declined by half from 2008 to 2011 and has since changed little, remaining near a historic low by all three indices.

VMS-based CPUE has been similar throughout most of the season for the past three years, although late season catch rates in July (i.e. weeks 13-16) of this year were above those of 2012, the most recent season similarly prolonging into summer (Fig. 61). Nonetheless, as measured against cumulative removals, fishery catch rates have been relatively unchanged during the past three years and lower than those of 2010-11.

Spatially, there have been few areas yielding high catch rates anywhere in the offshore in the past five years (Fig. 62). Although some areas continue to yield catch rates in the 10-15 kg/trap range, the majority of the grounds have been characterized by catch rates below 10 kg/trap. Interestingly, much of the area furthest offshore between the Belle Isle and Funk Island Banks (Fig. 58) became abandoned in 2014 (Fig. 62). Contraction of the spatial scale of the fishery while catch rates are low implies a poor situation for the exploitable biomass.

A voluntary bottom trawling closure area for the large vessel shrimp fleet, the Funk Island Deep (Fig. 58), has yielded catch rates similar to those exterior to it since its inception in 2005 (Fig. 63). This area traditionally yielded higher Snow Crab catch rates than those outside of it.

Although the result appears similar to the Hawke Box situation in Div. 2J, a conclusion that the closure has not benefitted Snow Crab resource or fishery productivity is confounded by the continuation of trawling by the small vessel shrimp fleet inside it since its inception. In this regard, the area is of little utility for assessing the impacts of its effectiveness.

Size distributions from at-sea sampling by observers (Fig. 64) show that modal CW has not changed since 2007. Generally, successive decreases across the entire size range of legal-sized crabs occurred from 2007-11 with little change since. The decline occurred in both the new-shell and old-shell components of the legal-sized population but was particularly evident in new-shell crabs beginning in 2009.

Observed incidence of soft-shell crab in the fishery has been particularly low throughout the season in the past two years (Fig. 65). During 2008-12, late-season fishing consistently yielded soft-shell incidences at or above the 20% grid closure threshold. The low incidence in the past two years, coupled with overall low catch rates of the most-competitive large hard-shelled males, implies further deteriorating recruitment prospects beyond the already low levels recently occurring.

Interestingly, recent events regarding potential recruitment in Div. 3K are somewhat similar to those in Divs. 2HJ, but the outcome has differed. Divs. 2HJ has also tended to encounter soft-shell crab incidence late in the season in most recent years (Fig. 51). In that division, annually decreasing levels of effort expenditure were associated with the consecutive incidences of late-season soft-shell. By inference, continuously reduced pre-recruit handling mortality was imposed by the fishery in recent years. In contrast, in Div. 3K, soft-shell catches first approached the 20% grid closure threshold in week 10 of the 2010 fishery, when about 70% of the total effort had been expended (Fig. 11). In 2011, soft-shell prevalence reached 20% in week 8 when about 80% of the total effort had occurred. Counter to the trend toward reductions in potential handling-induced mortality, in 2012 soft-shell incidence first reached 20% in week 8 and the fishery progressed for five weeks thereafter with soft-shell crab comprising 20-90% of the weekly catch. Over a third of the seasonal effort expenditure occurred during this time.

Handling mortality is not ascribed as the primary reason for the lack of recovery in the Div. 3K Snow Crab resource, a prolonged period of climate-induced low productivity is (Mullowney et al. 2014ab). However, the potential for negative top-down impacts from fisheries-induced mortality has remained relatively high here, and appeared especially high in 2012. In times of resource shortages improved efficiency and not prolonged periods of resource wastage is the recommended approach toward both maximizing short-term economic gains and promoting some rebuilding of the exploitable biomass.

High levels of soft-shell crab signify a strong approaching recruitment pulse, a depleted residual biomass, or both. Either way, the ratio of pre-recruits is high relative to exploitable crabs. With large, hard-shelled males thought to outcompete soft-shell crabs for baited pots, when the ratio favours pre-recruits, the potential for capturing, discarding, and likely killing crabs constituting short-term recruits becomes elevated. Such wastage is inefficient in extracting maximum gains from the resource. The soft-shell protocol is intended to protect the resource from such potential wastage, but has not been consistently effective in doing so.

Surveys

The post-season trawl and trap survey exploitable biomass indices have both declined steadily since 2008 to be at or near their lowest levels (Fig. 17, Table 5). This reflects low recruitment into the exploitable biomass, with poor recruitment occurring since 2009 (Figs. 21-22). Furthermore, recruitment is expected to remain low in the short term (2-3 years) with the post-season trawl and trap survey pre-recruit biomass indices having both declined since 2008 to their lowest levels (Fig. 23, Table 5).

Size frequency distributions from both the trawl (Fig. 66) and trap (Fig. 67) surveys show low and generally reducing levels of adolescent pre-recruit-sized males and a consistently depleting exploitable biomass since 2008. This reflects low resource productivity, with a low level of small crabs in the population since 2003 (Fig. 66). It is most likely that the last strong signal of high small crab abundance (i.e. < 30 mm CW) from 2000-02 was associated with the most recent level of high exploitable biomass that occurred in 2007-08 (Fig. 17). Accordingly, there has been a relatively low level of stock productivity and associated recruitment potential for over a decade here. In 2014, a higher level of small crabs was captured in the survey than has occurred in the past eleven years, signifying some increased long-term recruitment prospects for the fishery, but any increases in exploitable biomass to be gleaned from those crabs are a long way out. Nonetheless, it is important to monitor the extent to which this mode becomes established along with its progression through sizes to better understand the relative level of future improvements that may be expected.

Similar to Div. 2J, exploitable males here are found deep, predominately at fringe areas of the Funk Island Deep and St. Anthony Basin and their associated shallow water banks and plateaus (Fig. 68). The trawl survey distributions depict a situation where spatially the resource is contracting toward the western portions of the area, with progressively fewer crabs captured in far offshore areas in recent years. In 2014, few exploitable crabs were captured east of -52 degrees longitude, an area the fishery has also largely abandoned (Fig. 52). The same scenario holds for pre-recruit males (Fig. 69), which along with spatial contraction have also shown general reductions in catch magnitude throughout the division in recent years. In contrast to the progressively deteriorating signals of pre-recruit and exploitable males, a spatially broad-based increase in survey catch rates of small males has occurred throughout the division, both in shallow and deep water, in the past two years (Fig. 70). Similarly, although captures of mature females have been persistently infrequent, catch rates in 2014 appeared slightly elevated above recent norms (Fig. 71).

DIVISION 3K INSHORE

Fishery

The Div. 3K inshore fishery occurs in CMAs 3B, 3C, and 3D in bays and adjacent to the northeast coast of Newfoundland (Fig. 72). Landings (Fig. 73, Table 6) declined from 2,900 t in 2009 to 1,750 t in 2014, due to declines in CMA 3D (Notre Dame Bay) and 3C (Green Bay) where TACs were not taken in most of the past 5 years (Fig. 74). Overall, effort has declined since 2011, reflecting reductions in Green and Notre Dame Bays and variability in White Bay (Fig. 74).

Overall, fishery CPUE has been poor for the majority of harvesters in recent years (Fig. 75), remaining low during the past four years in Green (CMA 3C) and Notre Dame (CMA 3D) Bays, while it has been high in White Bay (CMA 3B) (Fig. 76). Observer coverage has been variable across management areas throughout the time series (Fig. 77). The criteria of a minimum of four weeks of non-consecutive coverage established for inclusion of data into the assessment was met in White Bay during the past three years and in the other two management areas during the past four years. With the exception of a lower observer CPUE estimate in Green Bay in 2013, observed CPUE has closely reflected logbook CPUE throughout the area in recent years (Fig. 76).

Seasonal depletion of the resource, as interpreted by declining catch rates throughout the fishery, has occurred during each of the past five years (Fig. 78). The late start in 2014 (i.e. Fig. 11) is reflected in the analysis of catch rates by week, whereby weekly catch rates were above or similar to those experienced in the five year time series. However, as measured against cumulative removals, the 2014 CPUE was at or near the lowest levels experienced in the past five years for most of the season. Spatially, this reflects poor performing fisheries in Green and Notre Dame Bays with catch rates below 5 kg/trap in all but the outer portions of Notre Dame Bay. Conversely, there was a more successful fishery in White Bay where catch rates were above 10 kg/trap throughout most of the area and above 25 kg/trap in some localized areas.

Similar to the offshore, the fishery has remained poor in most portions of Green and Notre Dame Bays for the past six years (Fig. 79), while it has experienced incredible swings in White Bay. The 2010 White Bay low in particular, when only about 50% of the TAC was taken and catch rates anomalously declined to 3 kg/trap, reflected a high incidence of soft-shell crab in the bay and the fishery was prematurely abandoned and closed. This was likely beneficial toward allowing a recruitment pulse to enter into the exploitable biomass with limited fisheries-induced mortality, and the harvesters are now realizing the benefits of those actions via the high catch rates in recent years.

Observer sampling suggests White Bay has been dominated by old-shell crabs since 2010 (Fig. 80). This is counter to the scenario of a strong recruitment pulse entering in 2010-12. The lack of new-shell crabs in the population in 2012 is particularly questionable. Despite little confidence in the reliability of shell condition classification by observers in this area, the progression of modal carapace size from 92 mm CW in 2010 to 104 mm CW in 2014 is consistent with the scenario of incoming recruitment.

Observer sampling in Green Bay suggests the abundance of most sizes of exploitable crabs declined from 2009-11 and has since been low. The knife-edge effect at legal-sized in size frequency distributions for the past six years (Fig. 80) suggests exploitation by the fishery has been very high for an extended period in this area. Further, the lack of new-shell crab in the population suggests recruitment into the exploitable biomass has been low in recent years. Counter to this, Notre Dame Bay has been dominated by large new-shell crabs for each of the past four years, suggesting the fishery has been capitalizing on incoming recruitment made available to it each year.

Fishery discards in White Bay have been dominated by under-sized old-shell and legal-sized soft-shell crabs in recent years (Fig. 81). The overall catch rates of discards has been much lower in the past two years than it had been for several years prior, suggesting that most of the recent recruitment pulse is now contributing to the fishery.

The low level of discards in Green and Notre Dame Bays for the past seven years is consistent with a low level of recruitment occurring here. With the exception of late-season anomalies in all areas, soft-shell crab levels have remained below the 20% grid closure threshold in the past three years (Fig. 82). The scenario in Green Bay, whereby catch rates of kept crabs have been low (i.e. about 5 kg/trap) and not opposed by increases in catch rates of soft-shell crabs is troublesome in indicating a continuation of poor recruitment prospects for the near future.

Overall, Green and Notre Dame Bays fisheries appear to be following the trajectory of the resource in the offshore, performing relatively poorly since peaks in the late-2000s. The White Bay population and fishery appears to be operating independently and is presently much more successful.

Surveys

The CPS trap survey indicates that the exploitable biomass has remained low in Green (CMA 3C) and Notre Dame (CMA 3D) Bays in the past four years (Fig. 83). The DFO trap survey indicates the exploitable biomass in White Bay (CMA 3B) has remained high (Fig. 84). Overall, as in the offshore, the exploitable biomass index was recently highest from 2006-08, and following a sharp decline in 2009 has since fluctuated at a lower level (Fig. 83). Annual variability in the overall exploitable biomass index from the CPS survey is influenced by events occurring within independent management areas. For example, a sharp increase in White Bay in 2012 contributed to an increase in the overall biomass index while the two other areas declined.

Recruitment has been low during the past 3-4 years in Green and Notre Dame Bays. It peaked at its highest level in 2012 in White Bay but has since declined. The DFO trap survey showed a sharp increase in catch rates of new-shell legal-sized crabs throughout White Bay in 2012 (Fig. 84). This was consistent in all three strata, extending from the shallow sill at the mouth of the bay (stratum 615) to its deep southern confines (stratum 613) (Fig. 72). This signal, reflecting a high level of incoming recruitment, was also captured in the CPS survey in 2012 (Fig. 85). However, since then the overall exploitable biomass indices of the two surveys have diverged, but the very low catch rate of old-shelled crabs in the 2014 CPS survey in White Bay appears anomalous. More intuitively, the DFO survey indicates that catch rates of old-shell crabs are now increasing in White Bay, chronologically succeeding the 2012 influx of crabs into the exploitable biomass. Although there is some disagreement in trends across the two surveys, both agree that White Bay is presently experiencing much higher catch rates, in the order of 12-20 kg/trap depending on depth, than either Green or Notre Dame Bays.

In Green and Notre Dame Bays, the DFO survey shows that the shallow water periphery area of stratum 611 (Fig. 72) has consistently yielded low catch rates. Most recently, survey catch rates peaked at about 8 kg/trap in 2008 but have since been steady at 3-4 kg/trap. This stratum dominates the fishing grounds of Green Bay and the two-decade long pattern in low catch rates suggests it is relatively marginal crab grounds for commercial fishing. Although there is some disagreement between the DFO and CPS trap surveys in Green Bay, with the CPS survey maintaining high catch rates until 2012 during the recent high (Fig. 85), trends in fishery CPUE infer the resource declined from 2008-11 (Fig. 76) and more closely reflect the DFO survey index.

The deep water channel of stratum 610 that is near exclusive to Notre Dame Bay (Fig. 72) has experienced both higher and more variable catch rates than the adjacent shallow-water grounds of stratum 611 and Green Bay. However, consistent with other areas, there is also some disagreement between the DFO and CPS surveys in Notre Dame Bay. Both surveys agree that the most recent peak in catch rates occurred in 2007 and that the exploitable biomass has been lower since (Fig. 84-85). However, the DFO survey showed a spike in 2012 that was not accounted for in the CPS survey. It is not clear which survey most accurately reflected true resource status, with fishery catch rates increasing slightly in both Green and Notre Dame Bays in 2013 (Fig. 76). Despite all the variability across surveys in recent years, 2014 point estimates consistently indicate that there has been little change in the status of the exploitable biomass in either Green or Notre Dame Bays from 2013-14, with both areas at relatively low levels.

Recruitment is expected to remain low in the short term in Green and Notre Dame Bays and to continue to decline in White Bay. The CPS trap survey index of pre-recruit biomass has declined in all three areas since 2010 (Fig. 83). For White Bay, unlike observer size frequency distributions, shell classification in the CPS trap survey reflected the emergence of a recruitment pulse into the exploitable biomass in recent years. This is seen in the progression of modal size of new-shell crabs from about 92 mm CW in 2010 to 107 mm CW in 2012 (Fig. 86). With very few sub-legal sized crabs captured in the past two years, it appears this recruitment pulse may now be near-fully contributing to the exploitable biomass. Further supporting this assertion is data from small-mesh traps in the DFO survey which show very few pre-recruit sized (i.e. > 75 mm CW) adolescents in the population in the past two years (Fig. 87). Although a forthcoming decline in recruitment appears imminent in the short-term in White Bay, the shallowest water stratum (615) captured a signal of small adolescent males ranging 44-50 mm CW in 2014. Most recruitment in White Bay is believed to originate from this shallow, cold water sill at the mouth of the bay, before crabs undertake ontogentic migrations through successive depth strata (i.e. Fig. 87). The level and rate of emergence and progression of this group of crabs will be important to track in the next few years to determine mid-term recruitment prospects.

In Green Bay, the CPS size frequency distributions agree with in-season observer sampling in showing a depleted residual biomass and heavy exploitation by the fishery, as interpreted by the knife-edge pattern at legal-sized (Fig. 86) in recent years. The dominance of old-shell crabs at sub-legal sizes are consistent with small-mesh traps from both the CPS and DFO surveys (Fig. 87) in showing that nearly all under-sized crabs in this area are terminally molted.

In Notre Dame Bay, the CPS survey size frequency distributions show little change in magnitude or composition of the exploitable biomass in the past four years, and small-mesh traps from the DFO survey indicate that while catch rate levels have been annually variable, there has been a consistent supply of sub-legal sized adolescent males in the population to contribute to the fishery each year (Fig. 88).

Although data are insufficient to estimate a pre-recruit fishing mortality index, trends in BCD, which commonly affects mid- and pre-recruit-sized crabs, have been at moderate to low levels in most of the area since 2009. In White Bay, very few crabs were infected in either stratum from 2009-13 (Fig. 89). However, prevalence increased to 10% in the shallow water stratum 615 in 2014. This is consistent with the emergence of a group of small crabs in that stratum (Fig. 88), as the density-dependent disease moderates recruitment most greatly during periods of high abundance (Mullowney et al. 2011). The high prevalence levels observed in the mid-2000s likely reflect the emergence and size/spatial progression of the recruitment pulse that recently entered the exploitable biomass and is now fueling the fishery. In Green (i.e. stratum 611) and Notre Dame Bays (i.e. strata 611, 610), spatiotemporal trends have been less clear (Fig. 89). The generally higher levels of BCD in the mid-2000s are consistent with higher levels of small- and mid-sized crabs in the population at that time. However, recent spikes in the shallow water stratum in 2011 and 2014 are not accounted for by the presence of increased abundances of small- and mid-sized adolescents in the population during those years (i.e. Fig. 88).

For fisheries-induced mortality, the post-season trap survey-based exploitation rate index has changed little in Notre Dame Bay, has declined in White Bay, and has increased sharply in Green Bay in the past two years (Fig. 90). Maintaining the current level of fishery removals would likely result in little change in the exploitation rate overall in 2015, with continued high exploitation in Green Bay.

Collectively, the fishery and survey data are beginning to reflect a situation whereby assessment and management area boundaries in Div. 3K do not conform well with the biology of Snow Crab. It is emerging that resource components in Green and Notre Dame Bays are tightly connected not only with one another but also to the broader-scale offshore. The deep-water channel extending out of Green Bay through Notre Dame Bay and into the offshore likely provides similar habitat and promotes an apparent high level of connectivity between areas. The fishery data reflect this, with catch rates in all areas similarly peaking in 2008, declining precipitously to 2011, and either improving slightly or being variable at a low level since (Fig. 60, 76). However, catch rates in Green Bay are generally lower than in the other areas and exploitation rates appear exceptionally high there.

Although most aspects of spatial connectivity, such as migration routes, are not understood, of potential concern is that the shallow waters of Green Bay could serve to source recruitment into the deeper adjacent channels of Notre Dame Bay and the offshore. If this is the case, excessive exploitation in Green Bay could exert direct or indirect impacts not only on Green Bay but adjacent areas as well. Spatial segregation by size is evident in crab populations in the northern portions of the NL shelf. Large-scale ontogenetic migrations, in the order of hundreds of kilometres with movement from shallow to deep areas over life, occur in both the Eastern Bering Sea (McBride 1982, Orensanz et al. 2004, Ernst et al. 2005) as well as the Barents Sea (personal communication, Ivan Zagorsky (VNIRO – Russia)), consistent with our observations from Divs. 2HJ and 3K. In the case of the Eastern Bering Sea, these movements have been shown to follow warm temperature fields (Orensanz et al. 2004, Ernst et al. 2005, Parada et al. 2010).

Adolescent males, and indeed crabs in general, tend to be smaller in Green Bay than in the other areas of Div. 3K, and shallow stratum 611 is colder than the surrounding waters (Mullowney et al. 2011). Based on the biology and behaviour of the species, it is suspected that crabs that do not undertake their terminal molt in the cold, shallow confines of Green Bay migrate out of it into the deeper warmer confines of Notre Dame Bay and the offshore and achieve larger sizes. This would be similar to how crabs in White Bay appear to move from shallow cold stratum 615 into the deeper and warmer waters of strata 614 and 613, and how crabs in Div. 2J appear to move from shallow nearshore plateaus and tops of banks into adjacent deep-water channels (i.e. Figs. 54 and 56). Further efforts to understand the connectivity of resource components in these areas are necessary.

DIVISIONS 3LNO OFFSHORE

The Fishery

The Divs. 3LNO offshore fishery occurs on and surrounding the Grand Bank off Newfoundland's southeast coast (Fig. 91). It is a massive, shallow, cold, and productive environment that encompasses CMAs NS, MS, MSex, 3Lex, 3Lex3N, 3Lex3O, 8B, 3L200, 3N200, and 3O200. Since the late-1990s there have been an estimated 1.2-2.2 million trap hauls per annum, with this area alone accounting for 40-55% of landings from the NL region.

Landings have remained near their highest level, at about 26,000 t, in the past three years (Fig. 92, Table 7). Effort declined considerably from 2011-13 but increased slightly in 2014 (Fig. 92, Table 7). CPUE increased from 2009-13 and changed little in 2014 (Fig. 93, Table 7) in all three indices. Overall, the fishery here has been performing well, maintaining landings and catch rates near all-time highs in recent years. Increasing CPUEs occurred in the Nearshore (CMA NS), Midshore (CMA MS), Midshore Extended (CMA MSex), 3L Extended (CMA 3Lex), 3L Outside 200 nm (CMA 3L200), and 3N Outside 200 nm (CMA 3N200) management areas from 2009 to 2013, with most decreasing slightly in 2014 (Fig. 94). Meanwhile, in opposition to the overall picture, catch rates in management area 8B have been gradually declining since 1998 and were at a two-decade low in 2014.

VMS-based CPUE has shown a great deal of weekly variability during the past five years but has generally been higher in the past two seasons than the preceding three (Fig. 95). Overall, there has been no suggestion of resource depletion during the fishery in any of the past five years, with no decline in CPUE as removals have accumulated. In 2013 and 2014 fishery CPUE remained above 500 kg/hour while about 22,000 t of Snow Crab was removed.

Since 2009, most effort has been expended across the northern portion of the Grand Bank in Div. 3L and along the Div. 3N slope edge, with lesser contributions occurring in isolated pockets of deep water near the central portions of the bank in management area 8B (Fig. 10, 96). There have been only subtle changes in the annual distribution of fishing effort, with 18-19% of the potential area fished during each of the last five seasons (Fig. 13). Similarly, there have been only subtle changes in timing of the fishery. It has begun in early- to mid-April (i.e. weeks 1-2) with most effort expended by early- to mid-July (i.e. weeks 14-15) during each of the past four years (Fig. 11).

Spatially, opposing trends in fishery catch rates have occurred in different areas of the bank since 2009. First, the majority of the fished area, incorporating the northern portion of the Grand Bank and the Div. 3N slope edge, has experienced greatly improved catch rates (Fig. 96). In many of these areas, catch rates were in the order of 5-10 kg/trap in 2009 and reached > 25 kg/trap by 2013. Although most of these areas maintained high catch rates in 2014, some of the fishing grounds in the canyons along the mid-portion of the Div. 3N slope experienced notable decreases back to about the 2009-10 level. In opposition to these generally improved fishing grounds dominating the area, the isolated pockets of effort in the mid and western portions of the bank in management area 8B have all experienced declining catch rates in recent years, from about 10-15 kg/trap in 2009 to 5-10 kg/trap in 2014.

Size distributions from at-sea sampling by observers reflected a platykurtic population in 2007 with no obvious primary mode (Fig. 97), when CPUE was in decline in most management areas. However, the shape and magnitude of the population distribution has changed considerably since then. In 2008, there was a shift in concentration, with a primary mode occurring at about legal-size. This shift coincided with an increase in the magnitude of catch rates of crabs 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 110 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 and establishment of a strong residual biomass over the past five years. Observer sampling data indicate that a relatively large increase in CPUE in 2010 was primarily due to an increase in new-shelled legal-sized crabs (Fig. 14), which has since remained similar in magnitude while the catch rates of old-shell animals has increased. The sharp 2012 increase in CPUE was due to increased catch rates of old-shell crabs (Fig. 14), which now comprise a higher proportion of the population (Figs. 14 and 97). The observer data suggest most of the recent recruitment pulse has now manifested itself in the exploitable biomass and a strong residual biomass has been built.

Soft-shell crab incidence in the fishery here is rarely a concern, especially in the past two years (Figs. 43 and 98), thus any reductions of recruitment into the exploitable biomass are less prone to top-down fishery interferences than in Divs. 2J3K and more clearly reflect bottom-up productivity factors. It is noteworthy that even in the latest stages of the fisheries of the past two years that soft-shell crab incidence did not approach 15% as it did from 2010-12. This further implies that the recent prolonged recruitment pulse has now near-fully contributed to the exploitable biomass.

Surveys

The indices of exploitable biomass from spring and fall trawl and trap surveys decreased, to differing degrees, in 2014 (Fig. 17) largely because recruitment has decreased since 2012 (Fig. 22). Recruitment is expected to decline further in the short term (2-3 years). The pre-recruit biomass indices from spring and fall trawl and trap surveys have declined since 2010 (Fig. 23). The overall picture is showing that the exploitable biomass has now peaked and a forthcoming decline is expected.

Size frequency distributions from fall surveys show two distinct pulses of high production of small crabs (i.e. < 30 mm CW) (Fig. 99), one at the beginning of the survey series in the mid-1990s and one from 2001-03. The 2001-03 pulse is likely associated with the recent influx of recruitment into the exploitable biomass, reflected by a relatively high level of pre-recruit adolescents (i.e. > 75 mm CW) in the size frequency distributions during 2008-10. As with most areas along the NL shelf, production has been relatively low since the early 2000s. A relatively small mode of young crabs centered at 12-21 mm CW occurred in 2010 (Fig. 100). This mode has subsequently begun to be tracked in small-mesh traps in the CPS survey, beginning in 2012 with a mode of crabs centered at 30 mm CW (Fig. 37). This bodes well for recruitment prospects in the next few years, as those crabs are now centered at 56 mm CW. During the last similar scenario in the late-2000s, the distribution of adolescent sizes was similar to present in 2007. The Divs. 3LNO offshore fishery CPUE began to increase in 2010 (Fig. 93), thus the present approaching mode may be expected to begin making contributions to the fishery in about 2017. However, this is uncertain as increases would first be expected to be seen in the pre-recruit biomass index, as occurred in 2008 (Fig. 23). It must further be cautioned that this recruitment pulse is only being detected in small-mesh traps near the Whale Deep (Fig. 91) in the western portion of the Grand Bank, thus broad-spatial contributions to the exploitable biomass and fishery may not be realized from it. For the western portion of the division specifically, the scenario of a low residual biomass, as interpreted from declining catch rates in CMA 8B (Figs. 94 and 96), and approaching recruitment, elevates the potential for soft-shell crabs and associated wastage in the fishery in this area in coming years. In the longer-term, as in Divs. 2J3K, there is a suggestion of the emergence of a pulse of small crabs in recent years, as seen in the 2014 spring survey (Fig. 100).

Large-mesh trap size frequency distributions from the CPS survey are similar to those from at-sea sampling by observers in showing that the recent recruitment pulse has made most of its contribution to the exploitable biomass. This is interpreted by the progression of the primary mode from 92 mm CW in 2008 to 100 mm CW in 2014 and an associated dissipation in the abundance of new-shell crabs in the population during the past two years (Fig. 101). Similar to most other data, the lack of reduction in most sizes of legal-sized crabs in the past three years infers a large residual biomass has been established and at present the fishery is not substantially depleting the biomass here.

The distribution of exploitable crabs in this division is very similar to that of fishery CPUE. Highest concentrations occur along the northern portion of the Grand Bank and the Div. 3N slope edge (Figs. 102-103). Of notable mention, despite an incomplete fall survey in 2014, the frequency and magnitude of catch rates along the Div. 3N slope has decreased in both the spring and fall surveys since 2012, where notable signs of a fishery decline began in 2014 (Fig. 96). Pre-recruit males have a similar distribution to exploitable males, virtually void in the shallow central portions of the bank and most commonly captured along the northern part of the bank and along the Div. 3N slope edge (Figs. 104-105). Their abundance has been decreasing throughout the division since about 2010-11 in both the spring and fall surveys.

Unlike in the deeper northern divisions, small males are spatially mixed with larger pre-recruit and exploitable-sized males along the northern portion of the Grand Bank in Div. 3L (Figs. 106-107). However, they are rarely captured in the deepest portion of the division along the Div. 3N slope edge. The magnitude of their catches has been relatively unchanged from 2009-14 with the exception of a broad-based increase in catch rates in the spring survey in 2014 (Figs. 106-107). Mature females are captured in sporadic fashion, generally in close association with mid-depth portions of the Grand Bank (Figs. 108-109). Although along the northern portion of the bank their distribution does extend down into greater depths where large males are commonplace, especially during spring (Fig. 109), they are more commonly captured slightly shallower than large males. The subtle spatial differences between their spring and fall distributions suggest they may migrate to deeper waters to be in closer association with males for breeding during spring. No clear trends have occurred in their abundance, although catch rates in the 2014 spring survey were higher than those seen since 2009 throughout most of the division.

DIVISION 3L INSHORE

Fishery

The Div. 3L inshore fishery occurs in coastal bays and near-shore regions within 25 nm of headlands off the east coast of Newfoundland (Fig. 110). It incorporates Bonavista Bay (CMA 5A), Trinity Bay (CMA 6A), Conception Bay (CMA 6B), Northeast Avalon (CMA 6C), Southern Avalon (CMA 8A), and St. Mary's Bay (CMA 9A). All but CMAs 6C and 8A are further sub-divided into inner and outer management areas but those finer-scale areas are not considered in the assessment. All the bays feature deep holes in their central interior portions. Bonavista and Trinity Bays are open at their mouths, thus the deep water inner portions are continuous with the offshore bathymetry, whereas Conception and especially St. Mary's Bays feature shallow sills at their mouths. The bathymetry in the areas east of the Avalon Peninsula is dominated by the Avalon Channel, a deepwater trough through which the southerly flowing cold inner branch of the Labrador Current passes. Overall, the bottom water here is cold (Fig. 5) and most of the area is characterized by productive Snow Crab grounds.

Landings have increased gradually since 2010 to a historical high of 8,000 t in 2014 while overall effort has declined (Fig. 111, Table 9). The recent overall high in landings reflects highs in all management areas except Bonavista Bay (CMA 5A) (Fig. 112). For effort, levels have been similar to historical norms in Bonavista and Trinity Bays, below average in Conception Bay and the Northeast Avalon, and at historical highs in the Southern Avalon and St. Mary's Bay (Fig. 112) in recent years.

CPUE has been near its highest level for the past three years (Fig. 113, Table 9) but there has been considerable variability among management areas. While Trinity and Conception Bays and the Northeast Avalon have all been increasing since 2010, and are at or near historic highs, the Southern Avalon has been declining, Bonavista Bay has remained at a low level, and St. Mary's Bay has been stable at an intermediate level of 15 kg/trap (Fig. 114). Observer coverage has been thinly distributed among the various management areas (Fig. 115) and no area has consistently achieved the minimum standard of four non-consecutive weeks of sampling in recent years for inclusion in the assessment. Annual observer CPUE estimates were plotted against logbook CPUE in areas and years when they were deemed acceptable for assessment (Fig. 114), and although trends were generally consistent with logbook estimates, point estimates varied considerably relative to other assessment divisions. Beyond these annual point estimates of CPUE, observer data were not utilized in the stock assessment in 2014.

CPUE has been low in Bonavista Bay in the past four years and steadily declined in the Southern Avalon since 2011. All other areas have shown stability at relatively high levels or increases to be at or near historic highs since 2008 (Fig. 115). At about 20 kg/trap in 2014, Conception Bay in particular has been performing very well. Increasing fishery catch rates coupled with increasing landings in Trinity and Conception Bays and the Northeast Avalon indicates the exploitable biomass has been particularly strong in those areas in recent years.

Overall CPUE indices have shown a pattern of slight depletion throughout the season in this division in most recent years (Fig. 116). CPUE tends to be highest at the beginning of the season, ranging from about 16-18 kg/trap in the past three years, and declines thereafter, generally finishing at about 8 kg/trap in the past five years (Fig. 116). The 2012-14 fisheries performed better throughout the season than the 2010-11 fisheries by weekly comparisons and as measured against cumulative removals. Biggest improvements have been realized at the start of the fisheries, particularly up to removal levels of about 3,000 t (Fig 116). Little potential bias introduced by differences in the timing of the fishery in recent years (Fig. 11) strengthens the conclusion that the fishery has overall performed very well in this division in the past three years. Areas of notable concern are the Southern Avalon and Bonavista Bay.

Spatially, the very high catch rates of the past three years have occurred in virtually all areas of Conception Bay and the Northeast Avalon (Fig. 117). Meanwhile, improvements in Trinity Bay have been near exclusive to the outer portions of it. For Bonavista Bay, fishery performance decreases occurred in most of the fishing grounds in 2014, but were most apparent in the outer portion of the bay. For the southern Avalon, despite a declining trend in CPUE, catch rates remained at or above 10-15 kg/trap in most of the area in 2014. Prolonged decreases in this area have been subtle and the exploitable biomass appeared to be very high from 2009-11 in most portions of the management area.

Surveys

The post-season trap survey index suggests the overall exploitable biomass has increased steadily since 2008 to its highest level in the time series (Fig. 118). Most management areas have experienced increases in recent years. A notable exception is Bonavista Bay (CMA 5A) which has declined since 2012 to its lowest level in the time series. The index of total exploitable crab catch rates from the DFO trap survey in Bonavista Bay has also decreased in the past two years and is near its lowest observed level (Fig. 119). Meanwhile, in Conception Bay the index has climbed to its highest observed level, primarily due to a build-up of residual old-shelled crabs in the population (Fig. 119).

Overall recruitment has declined gradually since 2010, although there is considerable variability among management areas. In Bonavista Bay, both the DFO and CPS surveys show an influx of new-shell legal-sized crabs into the biomass in 2011-12 that has since declined to a relatively low level (Fig. 120). In Trinity and St. Mary’s Bays, recruitment has been declining since 2010. Meanwhile, with the exception of a high catch rate of new-shelled legal-sized crabs in the southern Avalon in 2010, recruitment has been relatively steady in Conception Bay and the Northeast and Southern Avalon areas. It is noteworthy that the DFO survey in Conception Bay suggests recruitment has been decreasing there since 2009 and is at a recent low in the past two years.

In Bonavista Bay, size frequency distributions from large-mesh traps in the CPS survey depict a resource suffering from a recruitment shortage and being fished down, with decreases across the entire size range of legal crabs in the past two years (Fig. 121). Meanwhile, catch rates of most sizes of legal crabs have increased in Trinity and Conception Bays and in the Northeast Avalon. Off the southern Avalon, the abundance of legal-sized crabs appears steady in most recent years. This infers declining catch rates are largely a function of increased quotas and removals as opposed to a declining resource in this area. In St. Mary’s Bay, the size frequency distributions have broadened and become platykurtic in the past two years, with higher catch rates of largest crabs and reduced catch rates of small legal-sized crabs.

For most areas, similar to much of the offshore, there is an overall picture emerging of an established residual biomass, with size frequency distributions dominated by old-shell crabs.

This may not bode well for short-term recruitment prospects. Even under-sized crabs are predominately old-shelled and by inference terminally molted. This concern is best depicted by sub-legal-sized adolescents in small mesh traps in DFO and CPS surveys throughout the division. With the notable exception of Bonavista Bay, there were few sub-legal-sized crabs captured anywhere in 2014 (Fig. 122). Overall, recruitment is expected to decline further in the short-term (2-3 years). The post-season trap survey pre-recruit biomass index decreased in the past two years (Fig. 118) and an increasing proportion of it has been comprised of old-shelled crabs believed to be terminally molted. The dissipation of the most recent recruitment pulse into the exploitable biomass is especially clear in Trinity and St. Mary's Bays (Fig. 122), and no subsequent modes of adolescent males are apparent.

As in the offshore portion of Div. 3L (Fig. 39), BCD has decreased in prevalence in DFO survey monitoring in Conception Bay since 2005 (Fig. 123). Although beneficial for reduced natural mortality, this also signifies reduced abundance of intermediate-sized adolescent crabs in the population and is fully consistent with other trap data in indicating an expectation of a recruitment decline into the exploitable biomass and fishery in the next few years.

Overall fisheries-induced mortality has been consistent for the past decade. The post-season trap survey-based exploitation rate index has changed little over the time series, with considerable variability among management areas (Fig. 124). Interestingly, exploitation rates have converged in most management areas in the past three years, with the index ranging from about 10-30%. Conception Bay has declined substantially while all other areas have been more consistent each year since 2004. The only area increasing in 2014 was Bonavista Bay, which was at its highest level in the time series. With an increase in the overall exploitable biomass index (Fig. 118), maintaining the current level of fishery removals would likely decrease the overall exploitation rate in 2015.

Two notable items deserve discussion in Div. 3L inshore. First, Bonavista Bay (CMA 5A) appears to be following a different population trajectory than most of the division. Bonavista Bay is at the northern extreme of this division and waters are likely warmer. In recent years, trends in fishery CPUE (Fig. 115) have more closely reflected those of Div. 3K offshore (Fig. 60) and Green and Notre Dame Bays in Div. 3K inshore (Fig. 115). In recent times it appears less productive than the other areas of Div. 3L inshore. The push to maintain or increase quotas here (Fig. 112) appears to have exerted a stronger influence on the exploitable biomass than in other areas of this division. Second, a relatively large recruitment pulse has led to the build-up of a high abundance of old-shelled crabs in some areas such as St. Mary's and Conception Bays in recent years. Harvesters and managers are advised to give careful consideration into removal levels here. It is not known when these crabs will die from natural causes, but inefficiency in maximizing the yield-per-recruit gleaned from this resource could occur if they are not captured by the fishery in the next few years and a high proportion die naturally. It must be understood that there is a trade-off of an anticipated reduction in recruitment into the exploitable biomass in the near future. A strategy of attempting to allow the current residual biomass of old-shelled crabs to persist or decline only gradually from present levels could help bridge a gap and prolong fishing success on the current established residual component of the stock.

SUBDIVISION 3PS OFFSHORE

Fishery

The Subdiv. 3Ps offshore fishery occurs off the south coast of Newfoundland in shallow areas associated with the St. Pierre and Green Banks (Fig. 125). It incorporates CMAs 10BCD, 10X, 11S, and 11Sx. Overall, it is a shallow and cold area (Figs. 4-5). Landings (Fig. 126, Table 10) declined from a peak of 4,200 t in 2011 to 2,700 t in 2014. Meanwhile, TACs have not been taken and effort has increased to a record high level (Fig. 126, Table 10). CPUE increased from 2005 to 2009 and has since steadily declined to a record low in 2014 (Table 10, Fig. 127), with strong agreement in all three indices. Logbooks show that all management areas in the offshore are at low catch rates in recent years (Fig. 128). Generally, everywhere was about 5 kg/trap in 2015.

VMS-based CPUE throughout the season has deteriorated over the past five years (Fig. 129). By weekly measures, CPUE has been consistent in the past three years, beginning at about 250 kg/hour to start the season and finishing at about 150 kg/hour. However, this has been associated with a progressively declining amount of crabs being landed each year.

Spatially, there has been an expansion in area fished over the past five years, from about 12% of the potential grounds occupied in 2010 to about 17% in 2014 (Fig. 130). This expansion largely reflects increased effort in the southernmost portion of the St. Pierre Bank beginning in about 2012 and increased effort along the Divs. 3LO boundary lines to the northeast of the Green Bank in the past two years. The fishery has precipitously declined and performed very poorly throughout the entire division in recent years, with virtually all cells fished yielding catch rates below 5 kg/trap in 2014 (Fig. 130).

Size distributions from at-sea sampling by observers show a resource that has steadily declined since 2010 (Fig. 131). Of particular concern is the emerging ‘knife-edge’ effect near legal size in size frequency distributions in 2014, normally indicative of a high exploitation rate. With catch rates of about 1 kg/trap or less for each 3 mm CW bin, the observed population of legal-sized crabs appears very low. Observed incidence of soft-shell crab in the fishery has been persistently low throughout the season in the past six years (Fig. 132). Although this is positive in inferring relatively low wastage of the resource, at the low catch rate levels experienced in the past two years, it also raises serious concerns of a lack of forthcoming recruitment. If soft-shell pre-recruits were present at high abundance, they would be expected to trap under such low levels of residual biomass. All fisheries data are consistent in showing a very poor performing fishery and highlighting major concerns for the exploitable biomass in this division.

Surveys

The exploitable biomass, as indicated by the spring trawl and fall trap survey indices, has been at its lowest level during the past two years (Fig. 17, Table 11). This reflects declining recruitment in the form of new-shelled legal-sized crabs, with both trap and trawl surveys indicating recruitment has declined since 2009 (Figs. 21-22). The residual biomass, represented by intermediate to old-shelled legal-sized crabs, began to decline after 2010 (Figs. 21-22). Recruitment is expected to remain low in the short term (2-3 years) as pre-recruit biomass indices from both trap and trawl surveys declined rapidly from 2009 to their lowest levels in 2013-14 (Fig. 23, Table 11). However, an abundance index of intermediate-sized crabs (about 40-70 mm CW) from the post-season trap survey small-meshed traps suggests improved recruitment thereafter (Fig. 38). The leading tail of this mode would be expected to begin to achieve pre-recruit size (i.e. > 75 mm CW) in the next year.

The relative extent of change in the pre-recruit index in the next few years will be imperative to monitor. The last major mode of adolescents at similar size occurred in 2006, with the pre-recruit biomass index beginning to increase in 2007 (Fig. 23) and the exploitable biomass index in 2008 and most greatly in 2009 (Fig. 17). With the present exploitable biomass at such low levels, this approaching recruitment pulse poses great potential for wastage of crabs as soft-shell pre-recruits in the fishery. This mode emerged in trawl survey size frequency distributions at 12-30 mm CW from 2009-11 (Fig. 133) before beginning to be tracked in the CPS small-mesh traps. The signal of small crabs has since greatly dissipated, thus it is advisable to be as efficient as possible in the fishery over the next few years as the incoming recruits may not sustain the fishery for long.

Size frequency distributions from large-mesh traps in the CPS survey (Fig. 134) show a severely depleted exploitable biomass, particularly in the past two years, where the 'knife-edge' effect at legal-size has become firmly established. This is consistent with the very high pre-recruit and exploitation rate mortality indices occurring in the past two years (Fig. 41). Furthermore, the domination by old-shelled crabs at sub-legal-size indicates poor recruitment prospects for 2015.

Survey catch rates of exploitable and pre-recruit males began to occur in the southernmost portion of the division in 2010 (Figs. 135-136) and barren areas subsequently expanded progressively shoreward to the point where very few crabs of either category have been captured anywhere in the past two years. Smallest males began to notably decrease in the southernmost portions of the division and on the Green Bank in 2011, and following the last high signal along the northern portion of the St. Pierre Bank in 2012, their abundance has greatly decreased everywhere (Fig. 137). Mature female catch rates have been consistently sporadic (Fig. 138).

Like the fishery data, all survey data are consistent in showing a severely depleted resource in this division. Without major reductions in fishing effort in the next couple of years, there is great concern that the prospects for improvements, evident in the form of an approaching recruitment pulse, could be greatly reduced by pre-recruit fishing mortality before crabs have an opportunity to grow and harden to a commercially acceptable stage.

SUBDIVISION 3PS INSHORE

The Fishery

The Subdiv. 3Ps inshore fishery occurs in near-shore regions off the south coast of Newfoundland (Fig. 139). It incorporates CMAs 10A, 11E, and 11W. Placentia Bay (CMA 10A), to the east of the Burin Peninsula constitutes the primary fishing grounds. Landings (Fig. 140, Table 12) remained at 2,500 t from 2011-13 but decreased to 2,200 t in 2014. Effort has increased steadily since 2010 (Fig. 140, Table 12). The reduced landings were from CMAs 10A (Placentia Bay) and 11W, where TACs were not taken in 2014 (Fig. 141), while the increased effort primarily occurred in Placentia Bay (Fig. 141). CPUE remained at a high level from 2010-2012 but has declined sharply in the past two years (Fig. 142, Table 12).

Spatially, the fishery has expanded slightly in the past two years from about 12% of potential grounds covered to 15% (Fig. 13) and temporally there has been some potential bias introduced into catch rates by seasons that have been slightly delayed in the past two years relative to 2011-12 (Fig. 11). However, this would not seem significant enough to account for the dramatic drop in CPUE.

Largest decreases in CPUE in the past two years have been experienced in the main fishing grounds of Placentia Bay (CMA 10A) (Fig. 143). The historically poorer performing areas of Fortune Bay (CMA 11E) and CMA 11W both decreased slightly in 2014 but remain similar to levels seen throughout the mid-2000s. Observer coverage is consistently high in Placentia Bay (Fig. 144) with the other two areas receiving generally sparse and annually variable levels of coverage. In Placentia Bay, observed CPUE has tightly corresponded to logbook catch rates since the mid-2000s (Fig. 143).

Seasonal depletion of the resource, as interpreted by declining catch rates throughout the fishery, became more apparent in 2015 than in the preceding three years (Fig. 145). From

2011-13 there was a consistent pattern of catch rates declining after about week 12 (i.e. in June). However, in 2014, following an initial and typical increase in the first few weeks of fishing, catch rates declined precipitously from about 11 kg/trap in week 3 to 3 kg/trap in week 17. This catch rate analysis indicating a poorly performing fishery was associated with cumulative removals well below those of previous years. Spatially, with the exception of the eastern-most fishing grounds in Placentia Bay, catch rates were below 10 kg/trap throughout the entire area (Fig. 146). The precipitous decline in Placentia Bay, where in 2012 virtually the entire bay experienced catch rates at or above 15 kg/trap, is particularly striking.

Shell condition classification in size frequency distributions derived from at-sea observer sampling in Placentia Bay depicts a resource suffering from a lack of recruitment into the exploitable biomass. The proportion of new-shelled crabs in the catch has declined since 2011 and in 2014 virtually the entire population of both legal and sub-legal-sized crabs was old-shell (Fig. 147). Concomitantly, the abundance of legal-sized crabs has been steadily declining over the four year timeframe. The situation depicts one whereby the fishery is cleaning up an old-shell residual biomass and replacement via recruitment has been very low. This is consistent with weekly observations of soft-shell crabs in the catch, with virtually no soft-shell crabs seen in the area in the past four years either in the kept catch (Fig. 148) or in the discards (Fig. 149).

The scenario of low catch rates of legal-sized crabs coupled with a virtual absence of soft-shell pre-recruits and few new-shell animals in the population implies low recruitment and poor fishery prospects in the near future. The fishery here is experiencing a downturn similar to what occurred in the offshore, with the decline lagged by a few years (i.e. Figs. 127 and 142).

Surveys

The exploitable biomass, as indicated by the post-season trap survey index, declined since 2012 to its lowest level in eight years (Fig. 150). This reflects major declines of about 70-80% in the index in both Placentia Bay (CMA 10A) and Fortune Bay (CMA 11E) since 2012. Recruitment declined substantially in the past two years to its lowest level (Fig. 22). This reflects decreases in new-shell legal-sized crabs in both Placentia and Fortune Bays (Fig. 151). In Placentia Bay, recruitment has been declining in step-wise fashion since 2010 while in Fortune Bay the decline has been precipitous in the past two years. Meanwhile, the residual biomass, comprised of old-shell crabs, declined in all areas in 2014. The DFO survey captured very low total catches of about 1 kg/trap in all three depth strata of Fortune Bay in 2014.

Recruitment is expected to remain low for at least 2-3 years. The pre-recruit biomass index declined by more than half from 2007-11 and has since changed little (Fig. 150). The index has been dominated by old-shell crabs (i.e. 80-90%) in the past four years, inferring recruitment potential is very low. This can be seen in CPS trap survey size frequency distributions from large-mesh traps, whereby the sub-legal-sized mode of crabs in both bays is dominated almost entirely by old-shell animals in the past two years (Fig. 152). The low exploitable biomass in both bays is readily apparent in population distributions. Further, small-mesh size frequency distributions in both the DFO survey in Fortune Bay (Fig. 153) and the CPS survey in both bays (Fig. 154) are all consistent in showing very few adolescent crabs of any size greater than 35 mm CW in either bay in the past four years. Foreseeable recruitment prospects are bleak throughout Subdiv. 3Ps inshore.

The post-season trap survey-based exploitation rate index changed little from 2008-13 but nearly doubled in 2014 (Fig. 155). This reflects increases in both bays. Maintaining the current level of fishery removals would result in an increase in the exploitation rate in 2015. Data are insufficient to estimate a pre-recruit fishing mortality index. However, there appear few actual pre-recruits in the population at the present time.

As in the offshore, all survey and fishery data are consistent in showing a severely depleted resource in this subdivision. Unlike the offshore, there is no suggestion of an approaching recruitment pulse that raises the same level of concern about potential fisheries-induced mortality on pre-recruits in the near future. However, the offshore and inshore portions of Subdiv. 3Ps are inherently connected. The major productive fishing grounds are separated only by a management line at the southern limit of Placentia Bay (CMA 10A) and northern limit of CMA 10BCD. It is not unreasonable to expect that some budding prospects of increases in recruitment in the offshore over the next few years could extend into some portions of the inshore.

DIVISIONS 4R3PN OFFSHORE

Fishery

The Divs. 4R3Pn offshore fishery occurs along the west and southwest coasts of Newfoundland outside of eight nautical miles from the headlands (Fig. 156). The area comprises CMA OS8 and NAFO Subdiv. 3Pn, but there is little to no fishing in Subdiv. 3Pn. The bathymetry off the west coast is characterized by a shallow water nearshore plateau that borders the deep Esquiman Channel (Fig. 4). The bathymetry off the south coast is characterized by the presence of the Burgeo Bank extending through CMA 12A into Subdiv. 3Pn. Bottom temperatures in this area are the warmest along the NL shelf, and it is comparatively unproductive for Snow Crab. Fishery CPUE is consistently low compared to other divisions and the fishery tends to be opportunistic in nature, with harvesters choosing to prosecute it when commercial quantities of crab are believed to be present (i.e. Fig. 13).

Landings declined substantially from 580 t in 2004 to 80 t in 2006 before more than doubling in 2007. They declined by 83% from 190 t in 2007 to a historical low of 30 t in 2010, and increased to 300 t in 2013-14 (Fig. 157, Table 13). Effort increased by about a factor of seven since 2010 (Fig. 157, Table 13). The TAC has not been taken since 2002. VMS-based CPUE declined from 2004 to its lowest level in 2009 before increasing to its highest value in the time series in 2013 and declining slightly in 2014 (Fig. 158, Table 13).

The normal occurrence in recent years is for catch rates to peak early in the season and decline throughout (Fig. 159). In the past two years, although VMS catch rates have declined to a low level of about 25-50 kg/hour as per usual, the decline period has extended to a higher level of removals, up to about 175 t as opposed to the 110 t level of the previous two years.

The fishery in the offshore occurs in pockets tightly nestled against management lines of inshore areas as well as the northern Gulf of St. Lawrence (Fig. 160). This reflects the shallower waters in the periphery of the division, with little to no effort inside the Esquiman Channel. Catch rates have been at or below 5 kg/trap throughout the entire area for the past six years, reflecting the consistently marginal nature of the fishing grounds.

Survey

The assessment deemed the summer multi-species trawl survey unreliable for interpretation of trends in resource status due to consistently low and sporadic captures of Snow Crab. The CPS trap survey has been greatly reduced in spatial coverage in the past two years. Accordingly, survey data are insufficient to assess resource status.

DIVISION 4R INSHORE

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. 161). It incorporates CMAs 12A and 12B where little to no fishing occurs, Bay St. George (CMA 12C), Port-aux-Port Bay (CMA 12D), Inner (CMA 12F) and Outer (CMA 12E) Bay of Islands, Bonne Bay (CMA 12G) and CMA 12H. The fisheries here, in this warm region, are small in scale compared to most divisions. Similar to the offshore, the fishery tends to be opportunistic in nature, with effort expanding when catch rates are high and commercial quantities of crab are available, such as in recent years (Fig. 13).

Overall, landings have increased from a historical low of 155 t in 2010 to about 600 t in 2013-14 and effort has been stable for the past three years (Fig. 162, Table 14). The TAC has not been taken since 2002, but the near achievement of it in the past three years reflects a recently improved fishery, consistent in most areas (Fig. 163). Only CMA 12H was noticeably short in taking the quota in 2014. CPUE has been near an all-time high for the past three years (Fig. 164). This reflects relatively high levels of success in most management areas in the past three years, but especially Bay St. George (CMA 12C) and Bonne Bay (CMA 12G) where catch rates have remained above 10 kg/trap (Fig. 165). Most areas have experienced high fluctuations in catch rates over time, while CMA 12H has remained consistently low.

Fishery catch rates throughout the season grew progressively stronger from 2010-13, both in terms of weekly catch rates and those measured against cumulative removals (Fig. 166). However, in 2014 mid- and late-season catch rates were below those of 2013. A sharp decrease from about 10 kg/trap to 5 kg/trap occurred in week 5 at about 200 t of removals and things more gradually declined thereafter. This would not have been affected by differential fishery timing, with it progressing at a similar rate in the past three years (Fig. 11).

Surveys

The exploitable biomass index peaked in 2011 and has since declined to its previous level (Fig. 167). The overall trend is driven by Bay St. George (CMA 12C), but the biomass index in all areas has declined in the past three years. This is because recruitment has declined since 2011 to its lowest observed level (Fig. 22). This reflects a decline in abundance of new-shelled legal-sized crabs in all areas since 2011 or 2012 (Fig. 168). Only in Bay St. George (CMA 12C) and Bonne Bay (CMA 12G) has there been any suggestion of an increasing residual biomass following these relatively large recruitment spikes. This infers the fishery has been taking a high proportion of the incoming recruitment each year in most management areas.

Recruitment prospects are unfavourable in the short term (2-3 years). The trap survey index of pre-recruit-sized males peaked in 2009 and has since declined to its lowest level (Fig. 167). Overall, there is a clear picture of a fast progressing recent recruitment pulse approaching and progressing through legal-size in most of the management areas. This can be seen in both large- (Fig. 169) and small-mesh (Fig. 170) size frequency distributions from the CPS survey. Given that there is no indication of any subsequent approaching modes of adolescents in any area (Fig. 170), and large residual biomasses do not appear to have been established anywhere (Fig. 169), the fishery is likely to decline once again in the next few years.

The post-season trap survey-based exploitation rate index decreased in 2012 and has since changed little. However, maintaining the current level of fishery removals would result in an increase in the exploitation rate in 2015. This applies to all management areas.

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APPENDIX - TABLES

Table 1: Annual Overall (Divs. 2HJ3KLNOP4R) Total Allowable Catch and Landings by year.

YEAR	TAC(t)	LANDINGS(t)
1995	27,875	31,451
1996	34,864	36,702
1997	42,015	43,345
1998	49,225	50,467
1999	61,806	68,700
2000	51,169	55,151
2001	52,267	56,470
2002	56,981	58,735
2003	56,250	58,330
2004	53,590	55,609
2005	49,978	43,982
2006	46,233	47,257
2007	47,663	50,205
2008	54,338	52,734
2009	54,110	53,440
2010	56,087	52,199
2011	55,559	52,903
2012	52,990	50,474
2013	52,122	50,741
2014	51,611	49,820

Table 2: Annual Total Allowable Catch, Landings, Effort and CPUE for Divs. 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	588,372	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	238,679	10.6
2009	2,466	2,387	298,625	8
2010	2,227	2,131	280,395	7.6
2011	2,197	1,933	371,731	5.2
2012	1,952	1,606	281,754	5.7
2013	1,765	1,392	152,967	9.1
2014	1,765	1,736	209,157	8.3

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

YEAR	BIOMASS (t) - ESTIMATE	BIOMASS (t) - Upper	BIOMASS (t) - Lower	MEAN (kg/set)
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
2013	1527	2804	250	0.34
2014	4127	5545	2709	0.91

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

YEAR	BIOMASS (t) - ESTIMATE	BIOMASS (t) - Upper	BIOMASS (t) - Lower	MEAN (kg/set)
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
2013	975	1727	223	0.22
2014	299	592	65	0.66

Table 4: Annual Total Allowable Catch, Landings, Effort and CPUE for Div. 3K offshore.

YEAR	TAC(t)	LANDINGS(t)	EFFORT (trap hauls)	VMS CPUE (kg/hour)	Logbook CPUE (kg/trap)
1995	9,650	10,512	750,857	-	14
1996	9,700	11,083	846,031	-	13.1
1997	11,100	11,911	888,881	-	13.4
1998	12,700	14,103	946,510	-	14.9
1999	14,950	17,898	1,345,714	-	13.3
2000	11,218	13,056	1,186,909	-	11
2001	11,218	12,519	1,251,900	-	10
2002	12,183	12,870	1,191,667	-	10.8
2003	12,783	13,534	1,301,346	-	10.4
2004	12,823	13,584	1,787,368	221.4	7.6
2005	10,325	6,449	921,286	196.4	7.0
2006	8,295	8,496	745,263	312.0	11.4
2007	9,480	9,820	672,603	446.2	14.6
2008	12,305	12,292	754,110	415.8	16.3
2009	13,505	13,311	1,292,330	278.0	10.3
2010	11,720	10,173	1,105,761	235.8	9.2
2011	9,613	8,735	1,180,405	196.4	7.4
2012	7,318	6,496	914,930	167.9	7.1
2013	6,526	6,629	798,675	188.5	8.3
2014	6,038	6,063	739,390	207.6	8.2

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

YEAR	BIOMASS (t) - ESTIMATE	BIOMASS (t) - Upper	BIOMASS (t) - Lower	MEAN (kg/set)
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
2013	5213	7090	3337	1.27
2014	4638	6934	2342	1.13

Table 5b: Fall multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch, by year – pre-recruit crab in 3K offshore.

YEAR	BIOMASS (t) - ESTIMATE	BIOMASS (t) - Upper	BIOMASS (t) - Lower	MEAN (kg/set)
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
2013	2295	4119	471	0.56
2014	1877	2948	806	0.46

Table 6: Annual Total Allowable Catch, Landings, Effort and CPUE for Div. 3K inshore.

YEAR	TAC(t)	LANDINGS(t)	EFFORT (trap hauls)	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	2,244	477,447	4.7
2006	2,135	2,248	345,846	6.5
2007	2,270	2,450	247,475	9.9
2008	2,770	2,779	241,652	11.5
2009	2,970	2,873	354,691	8.1
2010	2,720	2,252	402,143	5.6
2011	2,440	2,009	410,000	4.9
2012	2,120	1,894	332,281	5.7
2013	1,923	1,890	242,308	7.8
2014	1,942	1,765	294,167	6.0

Table 7: Annual Total Allowable Catch, Landings, Effort and CPUE for Divs. 3LNO offshore.

YEAR	TAC(t)	LANDINGS(t)	EFFORT (trap hauls)	VMS CPUE (kg/hour)	Logbook CPUE (kg/trap)
1995	5,175	7,212	389,838	-	18.5
1996	7,100	8,494	534,214	-	15.9
1997	13,075	14,293	898,931	-	15.9
1998	13,250	15,111	873,468	-	17.3
1999	24,275	27,329	1,518,278	-	18
2000	20,502	22,083	1,150,156	-	19.2
2001	20,465	22,630	1,197,354	-	18.9
2002	22,333	23,528	1,258,182	-	18.7
2003	23,703	24,818	1,451,345	-	17.1
2004	23,703	24,656	1,700,414	479.2	14.5
2005	23,703	23,571	1,683,643	454.6	14
2006	23,703	24,526	1,777,246	432.8	13.8
2007	23,703	24,406	2,033,833	425.9	12.0
2008	24,148	23,421	2,110,000	322.7	11.1
2009	21,769	21,946	1,925,088	334.2	11.4
2010	24,835	24,136	1,736,403	390.8	13.9
2011	26,100	25,845	1,900,368	413.0	13.6
2012	26,490	26,141	1,613,642	441.1	16.2
2013	26,643	26,289	1,436,557	492.3	18.3
2014	27,023	26,530	1,607,879	511.6	16.5

*Table 8a: Fall multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch, by year – exploitable crab in 3LNO offshore. *Survey was incomplete in 2004 and 2014.*

YEAR	BIOMASS (t) - ESTIMATE	BIOMASS (t) - Upper	BIOMASS (t) - Lower	MEAN (kg/set)
1995	31835	40586	23085	3.09
1996	37462	45020	29905	3.68
1997	24526	30224	18827	2.39
1998	34292	42557	26027	3.33
1999	20816	25153	16478	2.04
2000	15709	20081	11337	1.53
2001	24495	31046	17945	2.38
2002	19295	25305	13286	1.88
2003	15365	19795	10936	1.50
2004	**9641**	**15671**	**3610**	**1.04**
2005	15750	27211	4290	1.53
2006	5023	6537	3510	0.49
2007	9714	14603	4825	0.94
2008	15022	19404	10641	1.46
2009	22406	31978	12834	2.18
2010	17871	27049	8692	1.74
2011	14865	19263	10468	1.45
2012	16007	22946	9069	1.56
2013	18577	27065	10089	1.81
2014	**6383**	**8856**	**3911**	**1.20**

*Table 8b: Fall multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch, by year – pre-recruit crab in 3LNO offshore. *Survey was incomplete in 2004 and 2014.*

YEAR	BIOMASS (t) - ESTIMATE	BIOMASS (t) - Upper	BIOMASS (t) - Lower	MEAN (kg/set)
1995	17765	23402	12128	1.72
1996	26732	36837	16627	2.62
1997	16272	61798	-29253	1.58
1998	20981	40905	1057	2.04
1999	10947	15720	6175	1.07
2000	9861	13290	6432	1.03
2001	10170	13419	6921	0.99
2002	5617	8558	2677	0.55
2003	8230	14105	2356	0.80
2004	**3849**	**9507**	**-1809**	**0.41**
2005	4552	7025	2079	0.45
2006	2646	3877	1415	0.26
2007	8076	11088	5063	0.78
2008	16372	23253	9492	1.60
2009	19041	26359	11724	1.85
2010	17590	27340	7841	1.72
2011	8816	42503	-24870	0.86
2012	7190	12113	2266	0.70
2013	6062	14319	-2196	0.59
2014	**859**	**1396**	**321**	**0.16**

Table 9: Annual Total Allowable Catch, Landings, Effort and CPUE for Div. 3L inshore.

YEAR	TAC(t)	LANDINGS(t)	EFFORT (trap hauls)	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	6,817	841,605	8.1
2004	6,255	6,420	823,077	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	7,094	662,991	10.7
2010	7,449	7,284	687,170	10.6
2011	7,122	7,069	648,532	10.9
2012	7,407	7,370	534,058	13.8
2013	7,708	7,603	520,753	14.6
2014	8,170	7,969	573,309	13.9

Table 10: Annual Total Allowable Catch, Landings, Effort and CPUE for Subdiv. 3Ps offshore.

YEAR	TAC(t)	LANDINGS(t)	EFFORT (trap hauls)	VMS CPUE (kg/hour)	Logbook CPUE (kg/trap)
1995	525	894	45,846	-	19.5
1996	1,700	1,665	99,701	-	16.7
1997	2,200	2,370	117,910	-	20.1
1998	3,700	3,257	134,033	-	24.3
1999	4,298	4,307	177,975	-	24.2
2000	4,400	4,386	212,913	-	20.6
2001	4,400	4,403	271,790	-	16.2
2002	4,400	4,357	360,083	-	12.1
2003	3,565	3,750	451,807	-	8.3
2004	2,805	3,419	422,099	216.2	8.1
2005	2,800	2,468	398,065	159.6	6.2
2006	2,070	2,324	297,949	179.5	7.8
2007	2,270	2,816	361,026	200.7	7.8
2008	3,230	3,098	279,099	256.3	11.1
2009	3,780	3,620	285,039	290.0	12.7
2010	4,305	3,874	333,966	276.7	11.6
2011	4,515	4,210	434,021	260.3	9.7
2012	3,925	3,703	416,067	212.7	8.9
2013	3,925	3,537	484,521	178.0	7.3
2014	3,247	2,696	550,204	164.7	4.9

*Table 11a: Spring multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch, by year - exploitable crab in Subdiv. 3Ps offshore. *Survey was incomplete in 2006.*

YEAR	BIOMASS (t) - ESTIMATE	BIOMASS (t) - Upper	BIOMASS (t) - Lower	MEAN (kg/set)
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
2013	143	219	66	0.06
2014	175	285	64	0.07

*Table 11b: Spring multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch, by year - pre-recruit crab in Subdiv. 3Ps offshore. *Survey was incomplete in 2006.*

YEAR	BIOMASS (t) - ESTIMATE	BIOMASS (t) - Upper	BIOMASS (t) - Lower	MEAN (kg/set)
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
2013	71	136	7	0.03
2014	65	163	-34	0.03

Table 12: Annual Total Allowable Catch, Landings, Effort and CPUE for Subdiv. 3Ps inshore.

YEAR	TAC(t)	LANDINGS(t)	EFFORT (trap hauls)	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	2,368	415,439	5.7
2004	1,590	1,301	371,714	3.5
2005	1,300	704	207,059	3.4
2006	975	781	195,250	4.0
2007	975	1,147	204,821	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	2,512	2,506	192,769	13.0
2012	2,542	2,522	181,439	13.9
2013	2,542	2,510	224,107	11.2
2014	2,330	2,208	310,986	7.1

Table 13: Annual Total Allowable Catch, Landings, Effort and CPUE for Divs. 4R3Pn offshore.

YEAR	TAC(t)	LANDINGS(t)	EFFORT (trap hauls)	VMS CPUE (kg/hour)	Logbook CPUE (kg/trap)
1999	645	629	149,762	-	3.7
2000	645	674	134,800	-	4.2
2001	635	649	147,500	-	5
2002	845	977	195,400	-	4.4
2003	845	610	169,444	-	5
2004	838	584	182,500	124.9	3.6
2005	845	348	108,750	119.4	3.2
2006	675	79	27,241	91.6	3.2
2007	540	193	74,231	90.2	2.9
2008	540	131	42,258	83.3	2.6
2009	418	68	29,565	73.4	3.1
2010	418	33	10,000	106.6	2.3
2011	414	149	51,379	77.0	3.3
2012	418	191	48,974	95.9	2.9
2013	418	299	66,444	113.1	3.9
2014	418	264	71,351	97.7	4.5

Table 14a: Summer multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch, by year – exploitable crab in Divs. 4R3Pn offshore.

YEAR	BIOMASS (t) - ESTIMATE	BIOMASS (t) - Upper	BIOMASS (t) - Lower	MEAN (kg/set)
2004	111	292	-70	0.15
2005	82	273	-109	0.15
2006	180	431	-72	0.22
2007	92	261	-77	0.11
2008	174	552	-205	0.22
2009	229	1099	-640	0.28
2010	80	188	-28	0.10
2011	365	820	-90	0.45
2012	175	452	-101	0.22
2013	52	277	-173	0.06
2014	125	447	-196	0.15

Table 14b: Summer multi-species survey exploitable and pre-recruit biomass indices with confidence intervals and mean catch, by year – pre-recruit crab in Divs. 4R3Pn offshore.

YEAR	BIOMASS (t) - ESTIMATE	BIOMASS (t) - Upper	BIOMASS (t) - Lower	MEAN (kg/set)
2004	195	917	-527	0.26
2005	14	74	-46	0.02
2006	46	116	-24	0.06
2007	54	260	-151	0.07
2008	52	121	-17	0.06
2009	74	337	-189	0.09
2010	18	52	-16	0.02
2011	94	222	-34	0.12
2012	36	79	-8	0.04
2013	90	377	-197	0.11
2014	19	60	-23	0.02

Table 15: Annual Total Allowable Catch, Landings, Effort and CPUE for Div. 4R inshore.

YEAR	TAC(t)	LANDINGS(t)	EFFORT (trap hauls)	CPUE (kg/trap)
1998	1,310	1,067	197,593	5.4
1999	690	988	161,967	6.1
2000	785	954	194,694	4.9
2001	909	1,026	183,214	5.6
2002	904	878	104,524	8.4
2003	972	928	116,000	8
2004	998	841	133,492	6.3
2005	972	508	80,635	6.3
2006	860	435	72,500	6.0
2007	750	365	101,389	3.6
2008	700	234	49,787	4.7
2009	483	200	48,780	4.1
2010	482	155	41,892	3.7
2011	615	447	95,106	4.7
2012	641	551	68,025	8.1
2013	641	592	62,316	9.5
2014	1,310	1,067	197,593	5.4

APPENDIX - FIGURES

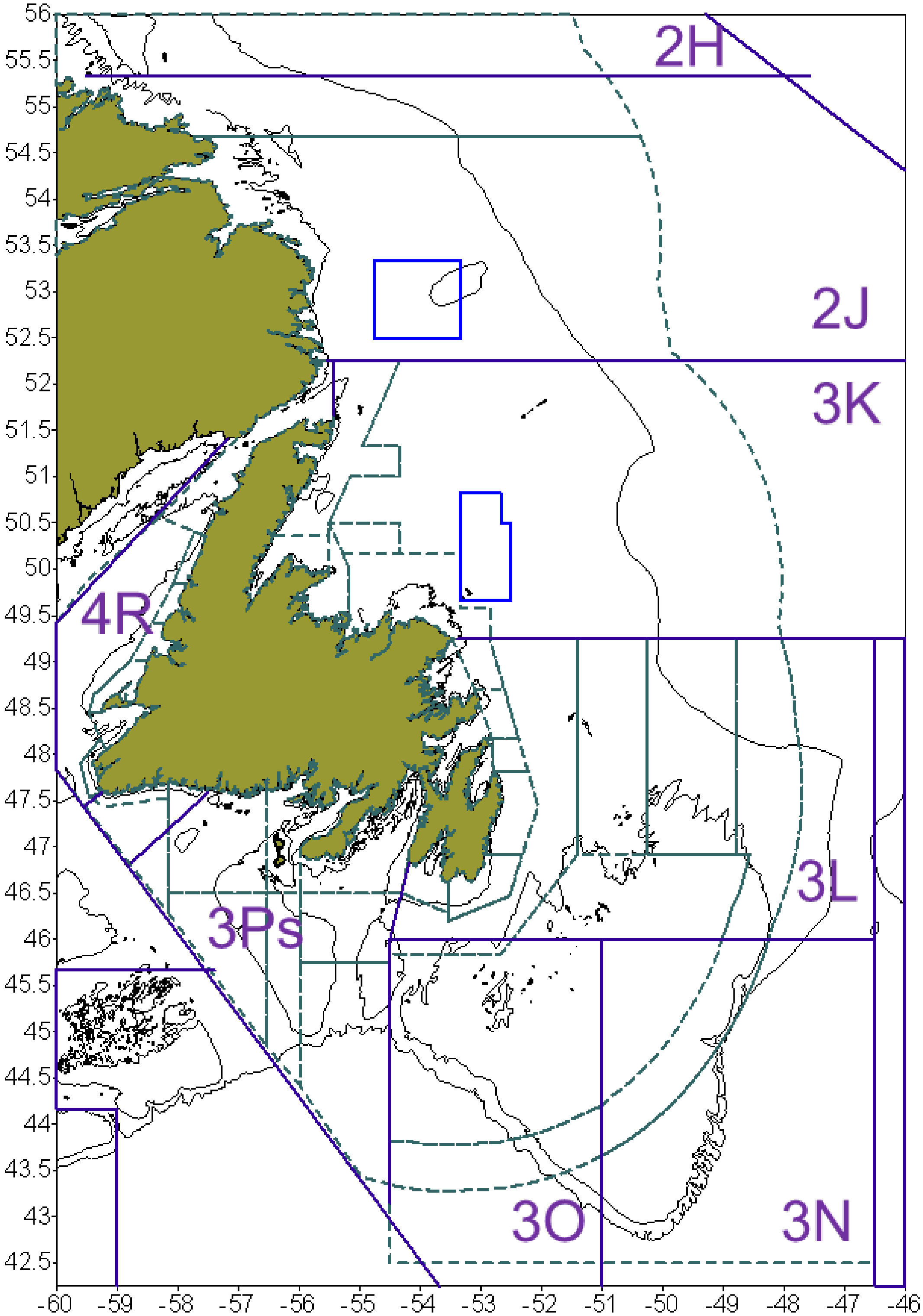


Figure 1: NAFO divisions (purple lines), Newfoundland and Labrador Snow CMAs (green lines), trawling and gillnetting closures (blue boxes), and bathymetry of the Newfoundland and Labrador shelf (grey underlay).

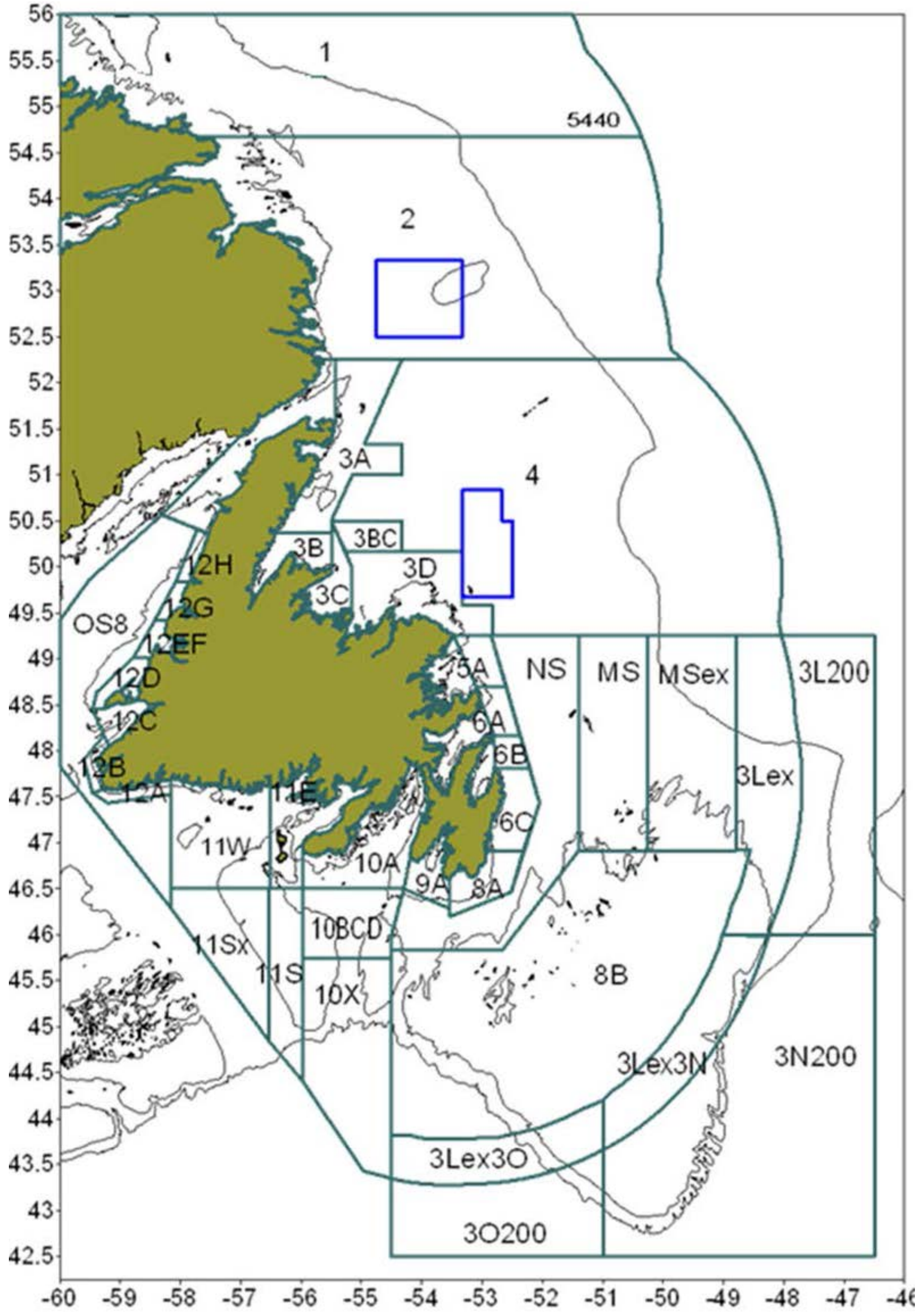


Figure 2: Newfoundland and Labrador Snow CMAs.

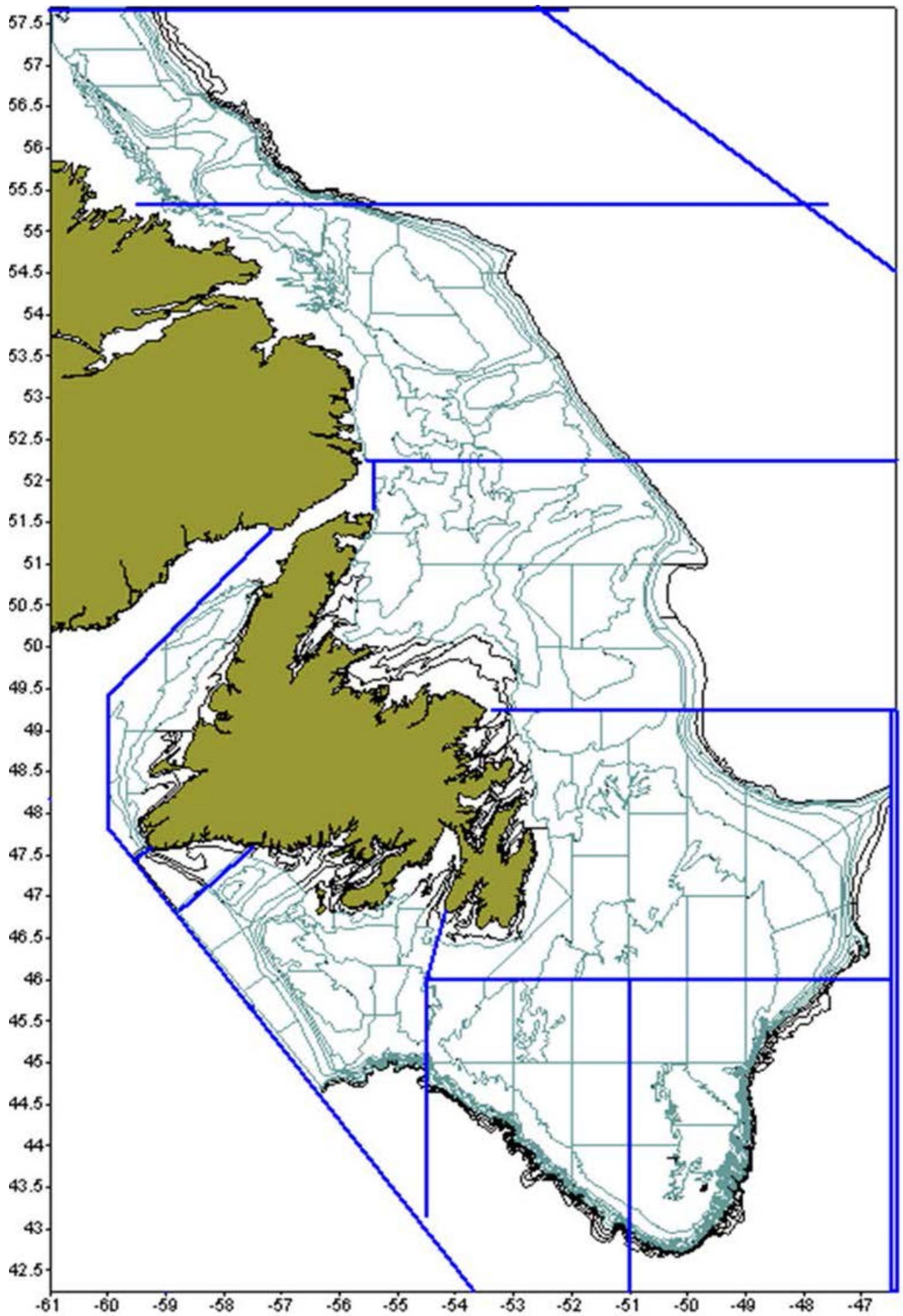


Figure 3: DFO multi-species trawl survey strata. Core strata shown in teal.

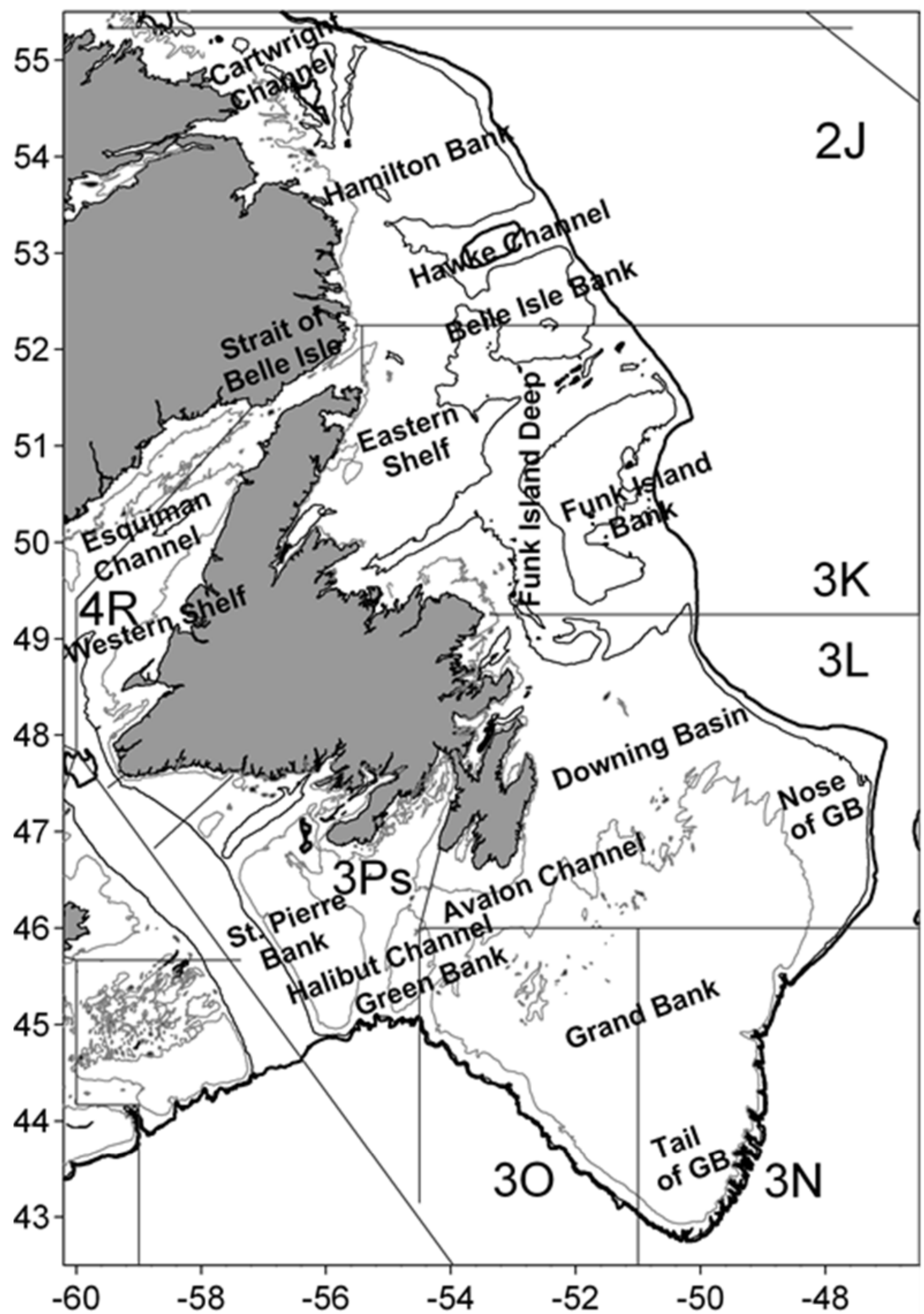


Figure 4: Map of Newfoundland and Labrador Continental Shelf showing place names and bathymetrical features.

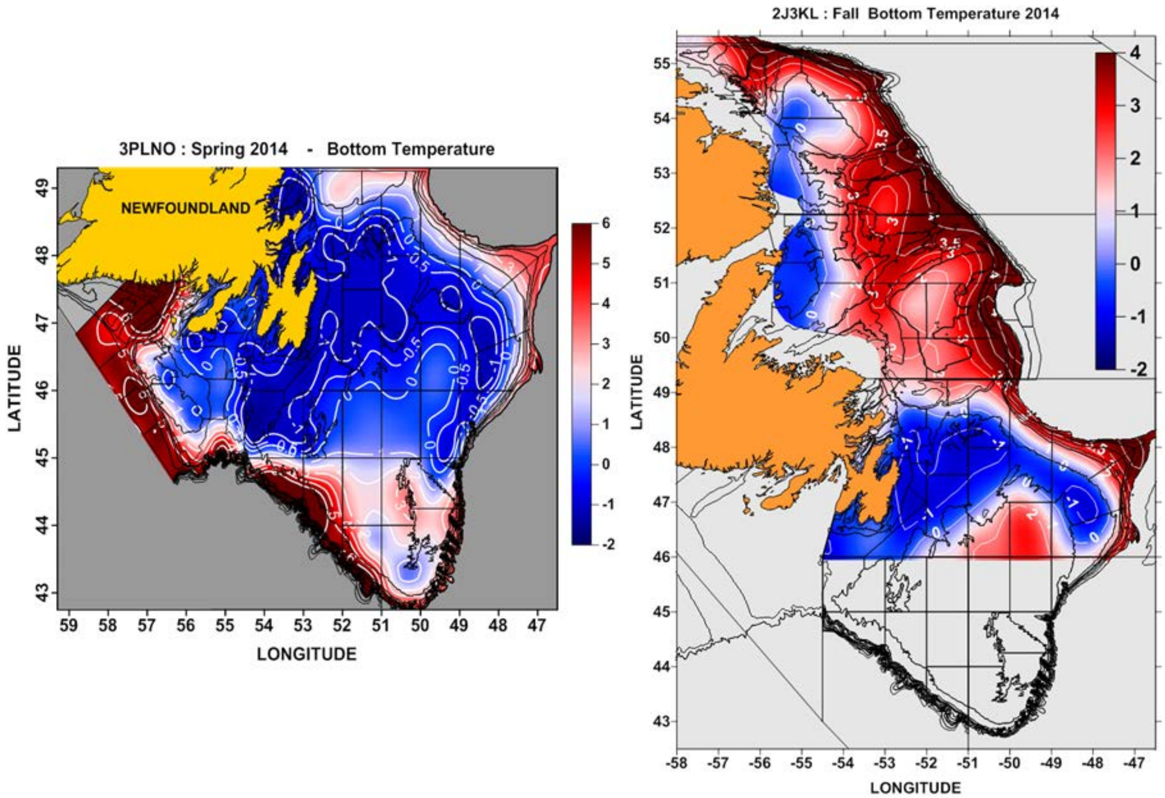


Figure 5: Maps of bottom temperatures along the Newfoundland and Labrador shelf during spring (left map) and fall (right map) from multi-species trawl surveys in 2014.

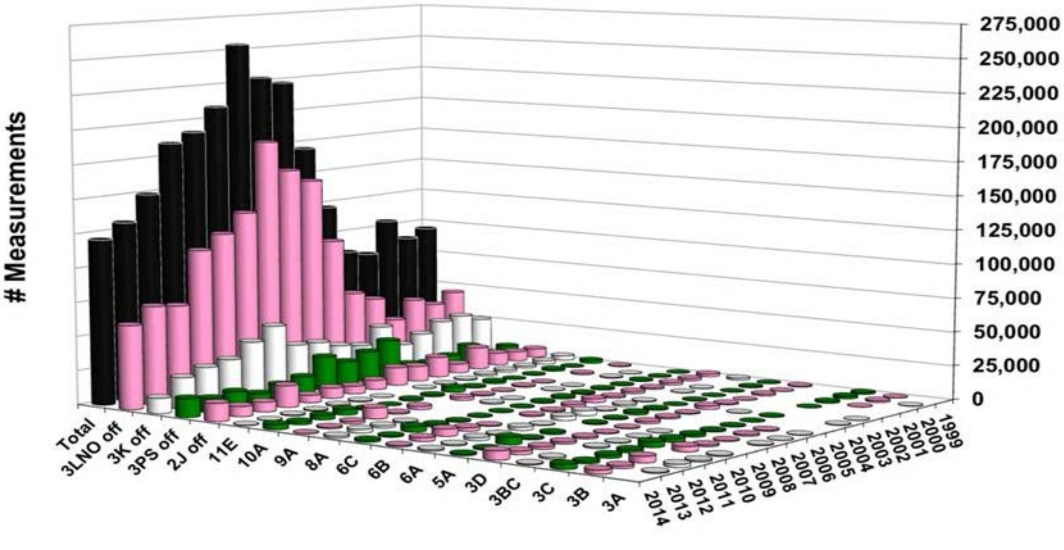


Figure 6: Observer sampling by CMA and year. Data pooled for offshore CMAs in each division.

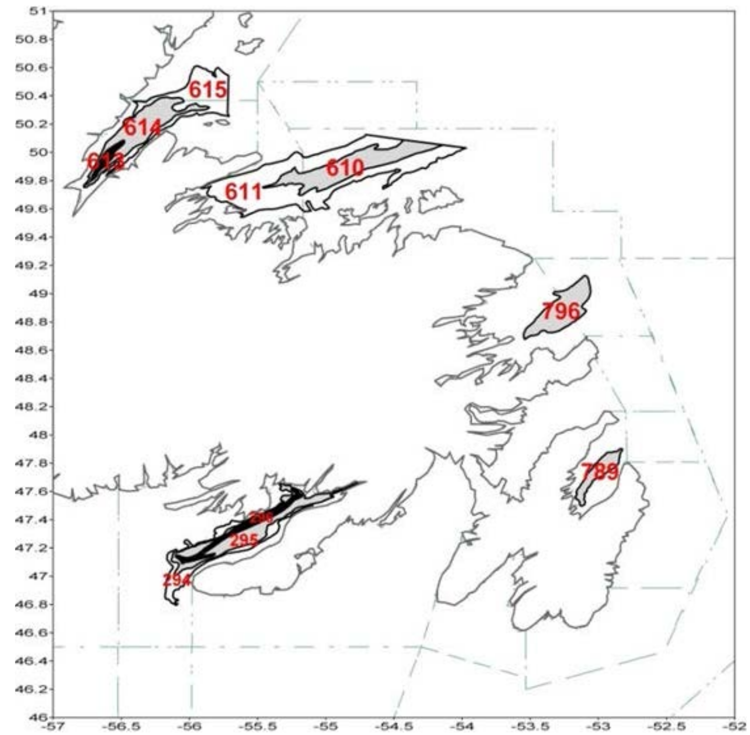


Figure 7: Strata sampled during DFO inshore trap and trawl surveys.

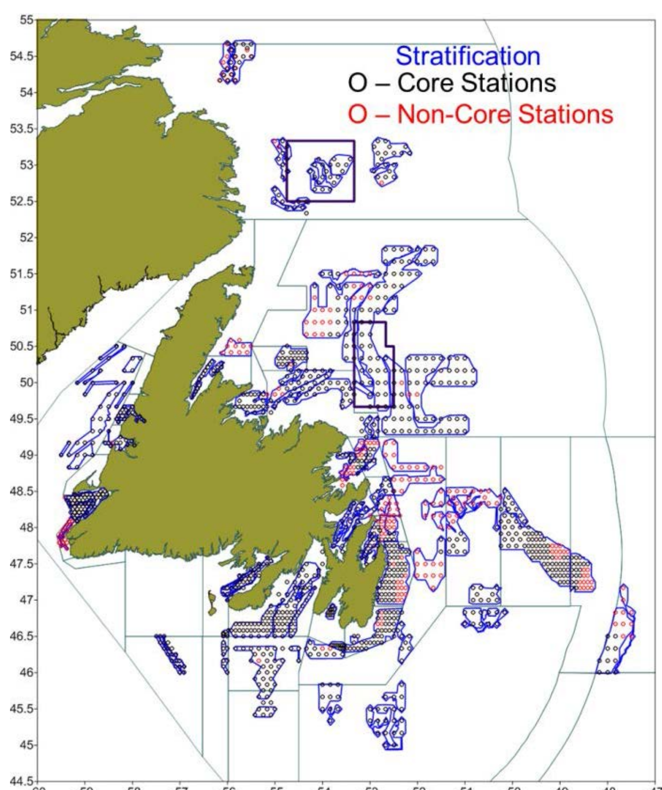


Figure 8: Industry – DFO Collaborative Post-Season trap survey showing occupied and core stations as well as stratification scheme used for data analyses.

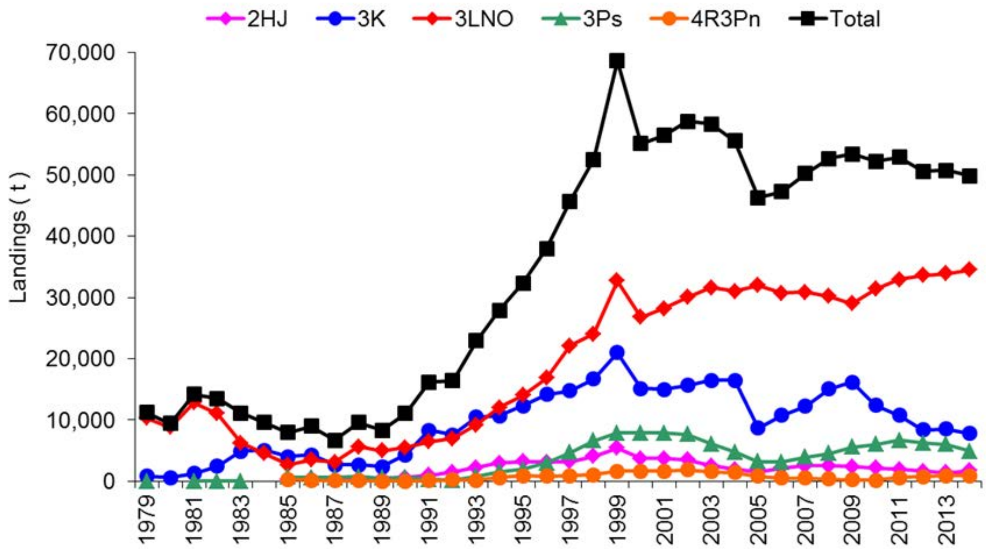


Figure 9: Trends in annual landings by NAFO division and in total.

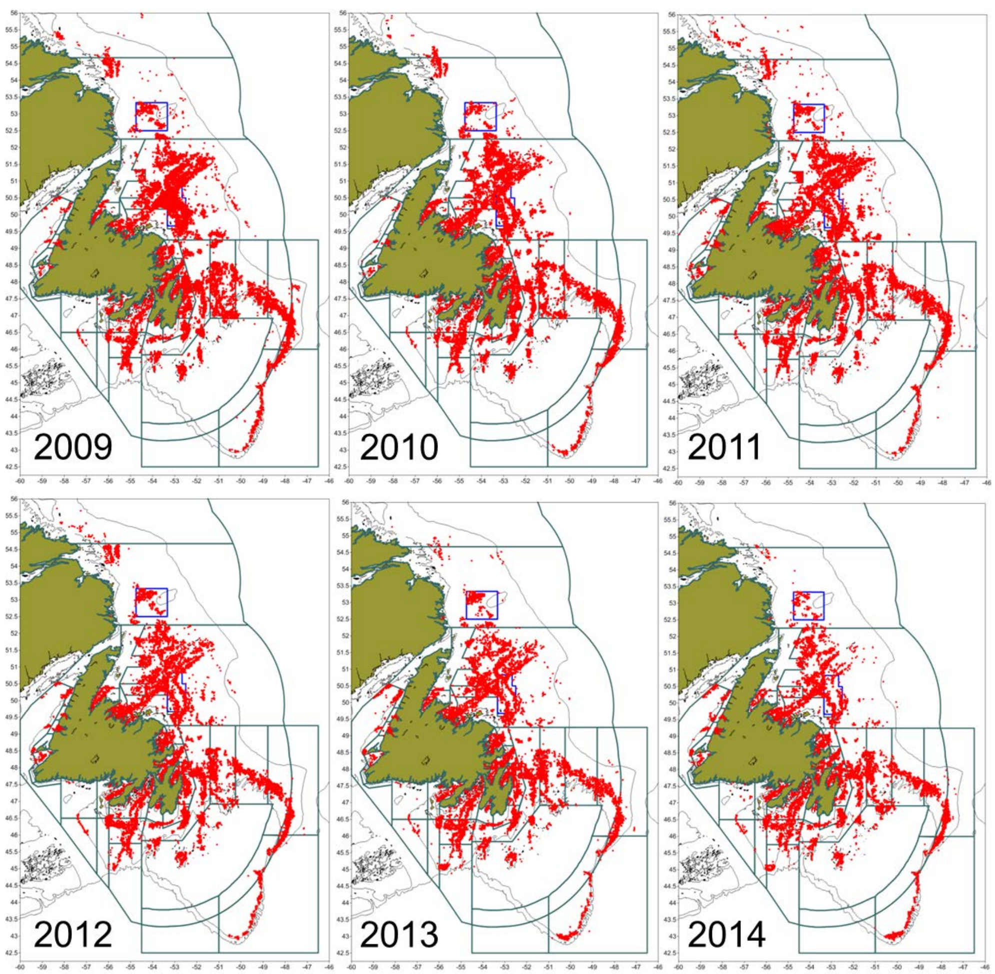


Figure 10: Distribution of logbook fishing effort from 2009-14.

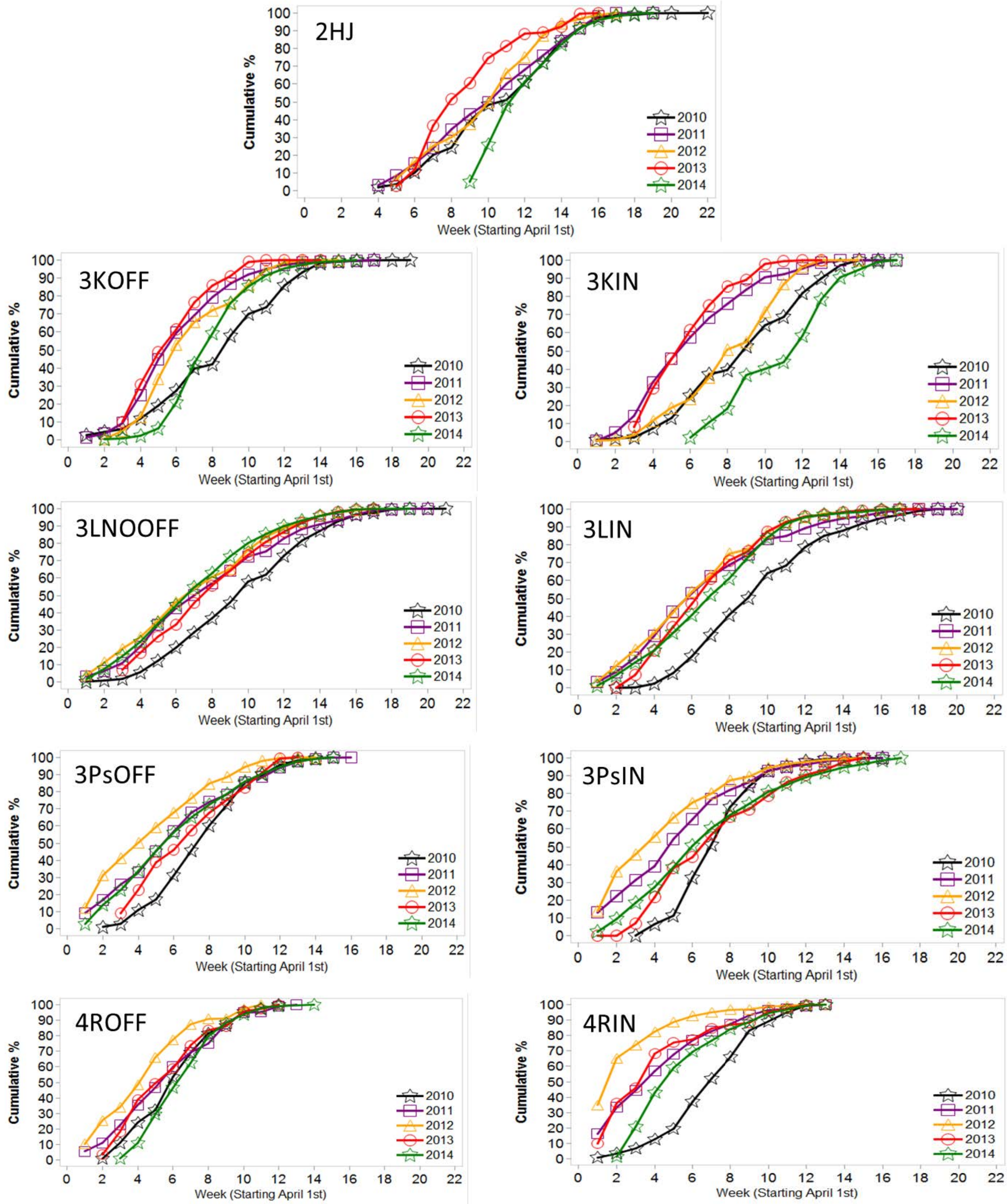


Figure 11: Seasonal trends in weekly fishing effort for each division from 2010-15.

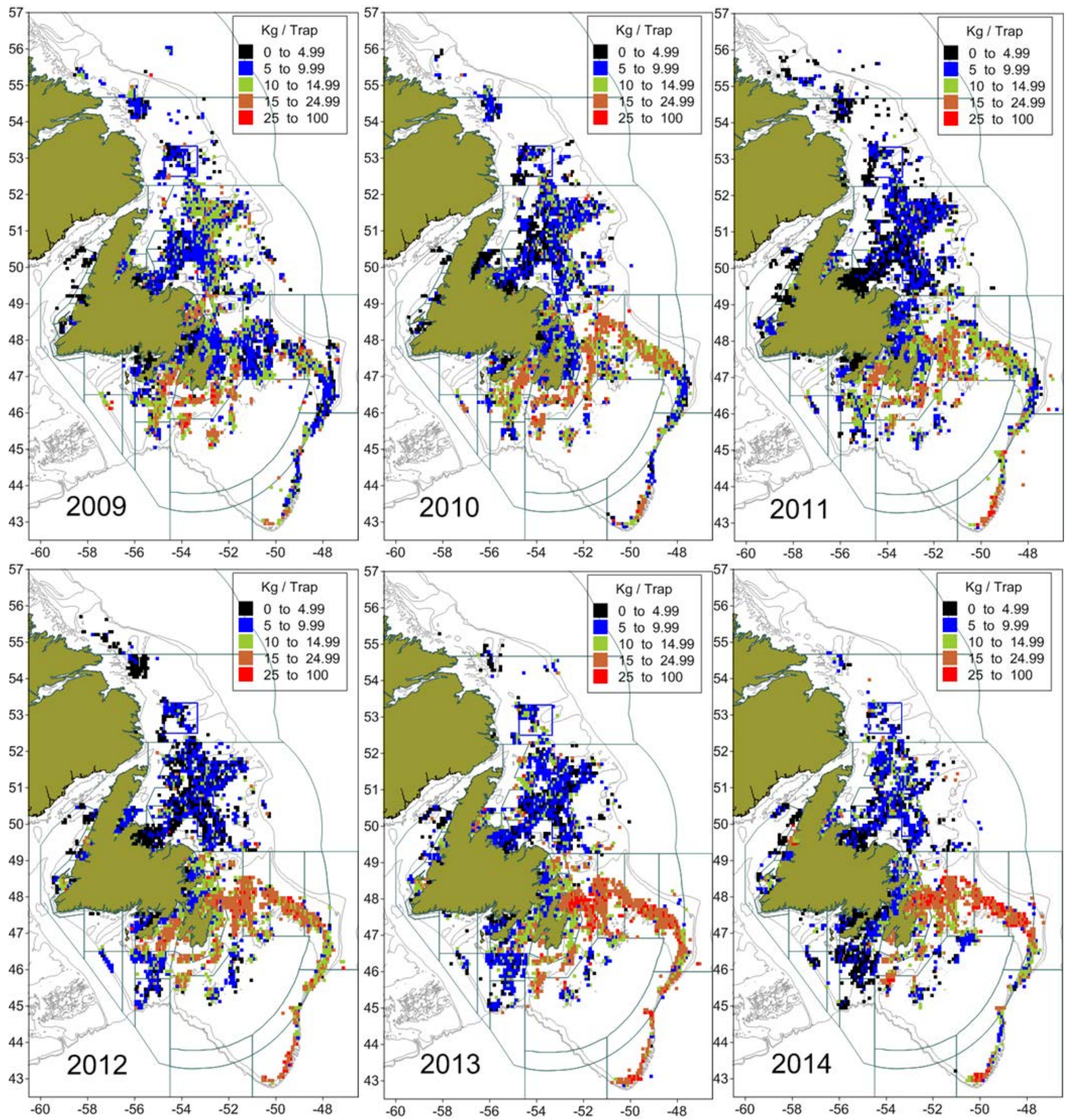


Figure 12: Spatial distribution of logbook CPUE by year.

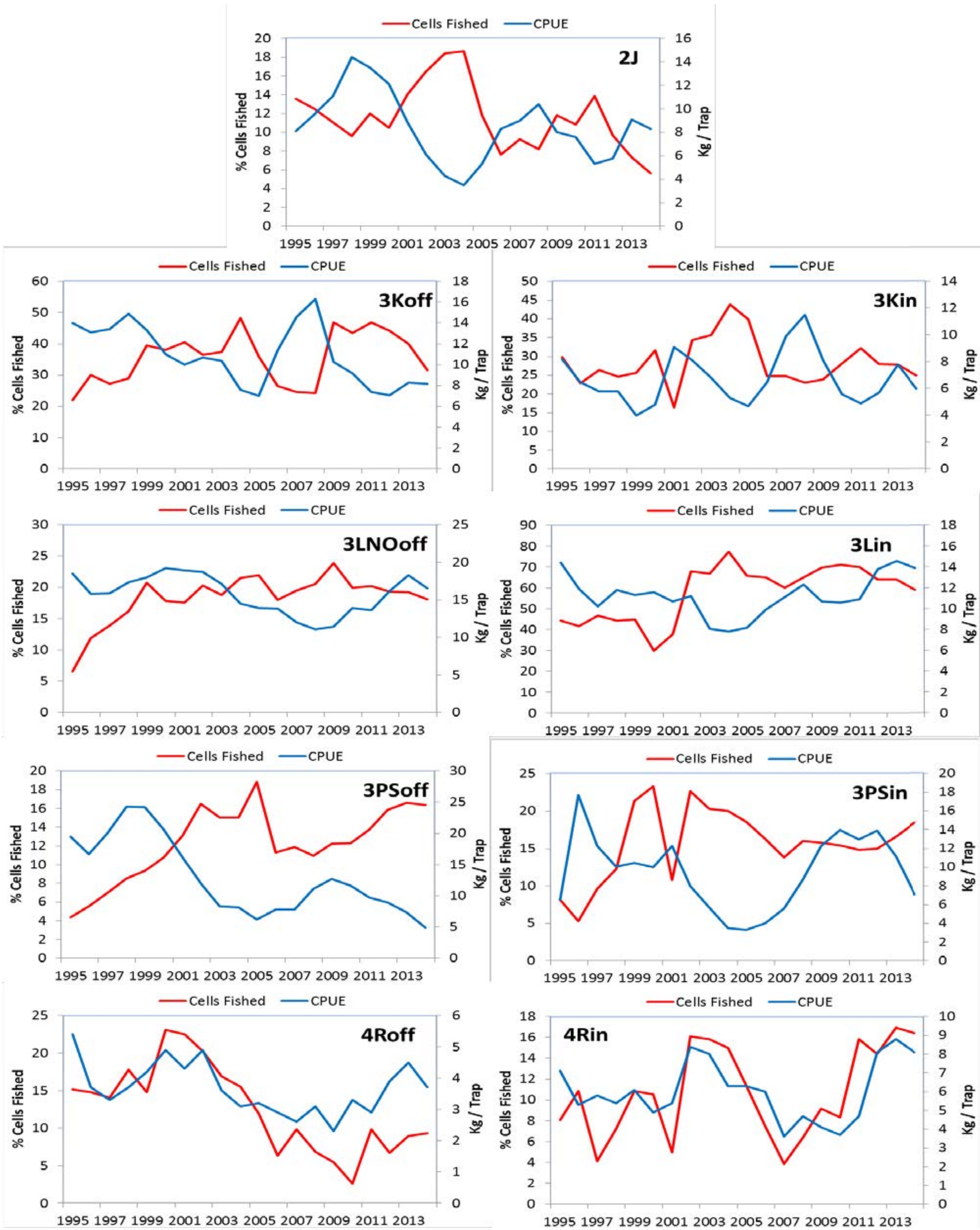


Figure 13: Trends in commercial CPUE vs. the percentage of 5' x 5' cells fished in each assessment division.

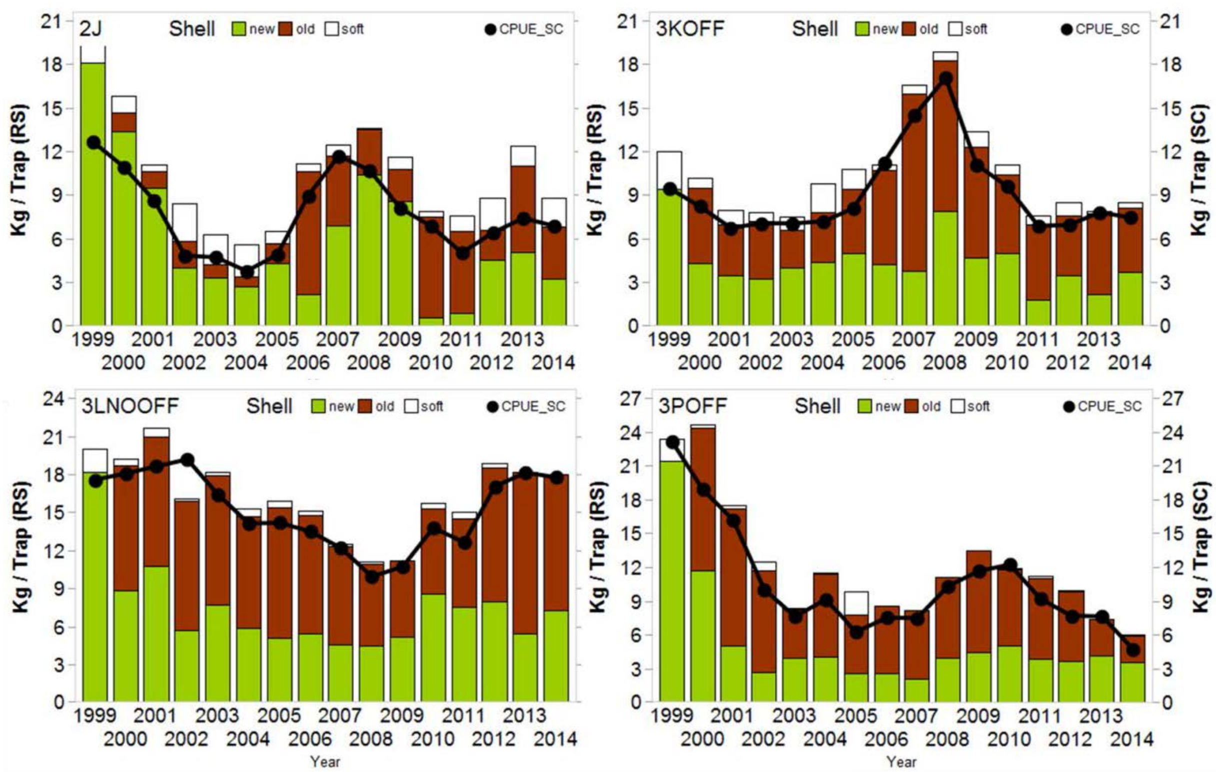


Figure 14: Trends in catch rates of legal-sized crabs by shell condition from observer at-sea sampling and of all crabs kept based on set and catch records (sc) for offshore assessment divisions.

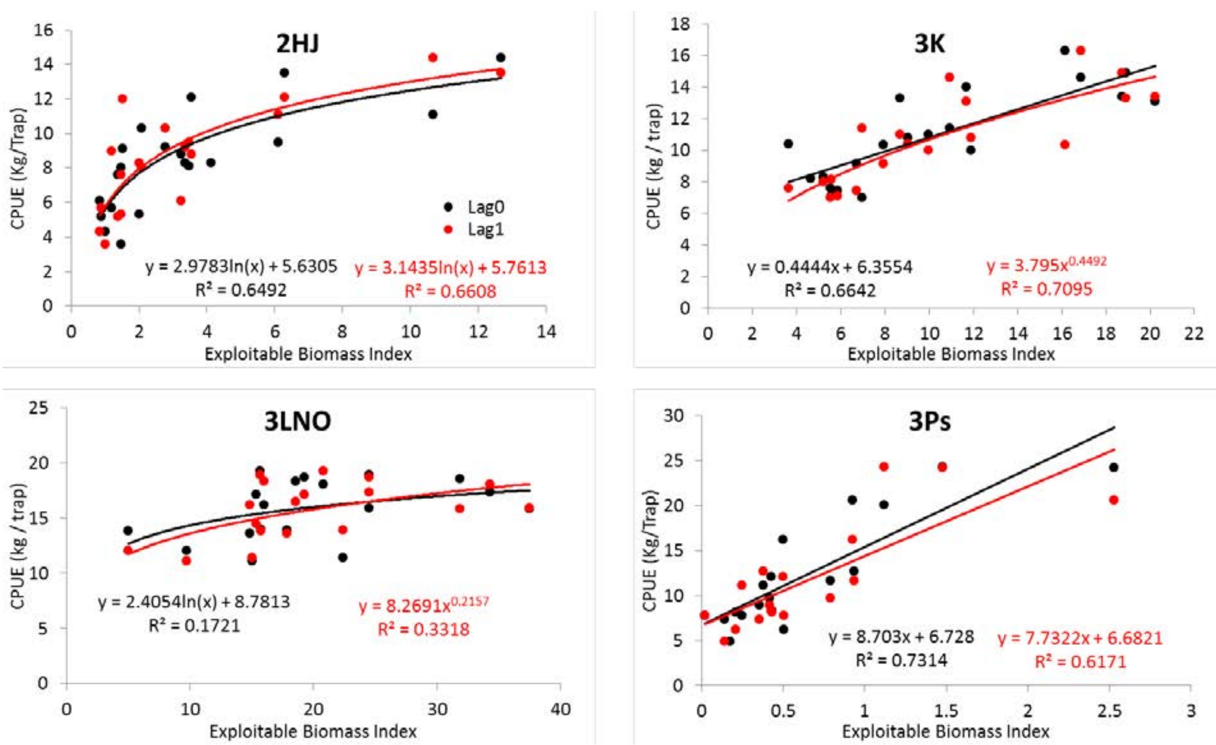


Figure 15: Relationships of logbook CPUE vs. trawl survey exploitable biomass indices at Lags of 0 and 1 years for offshore assessment divisions from 1995-2014.

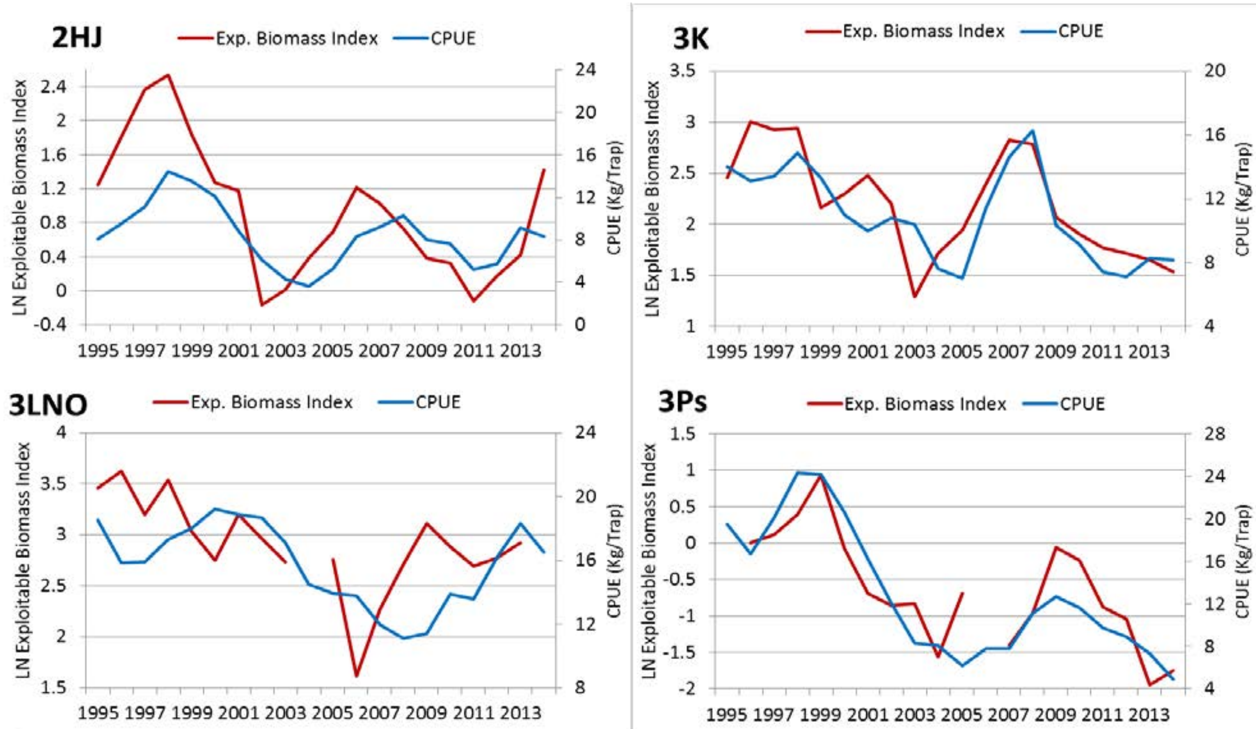


Figure 16: Logbook CPUE vs. trawl survey exploitable biomass indices at Lags of 0 and 1 years for offshore assessment divisions from 1995-2014.

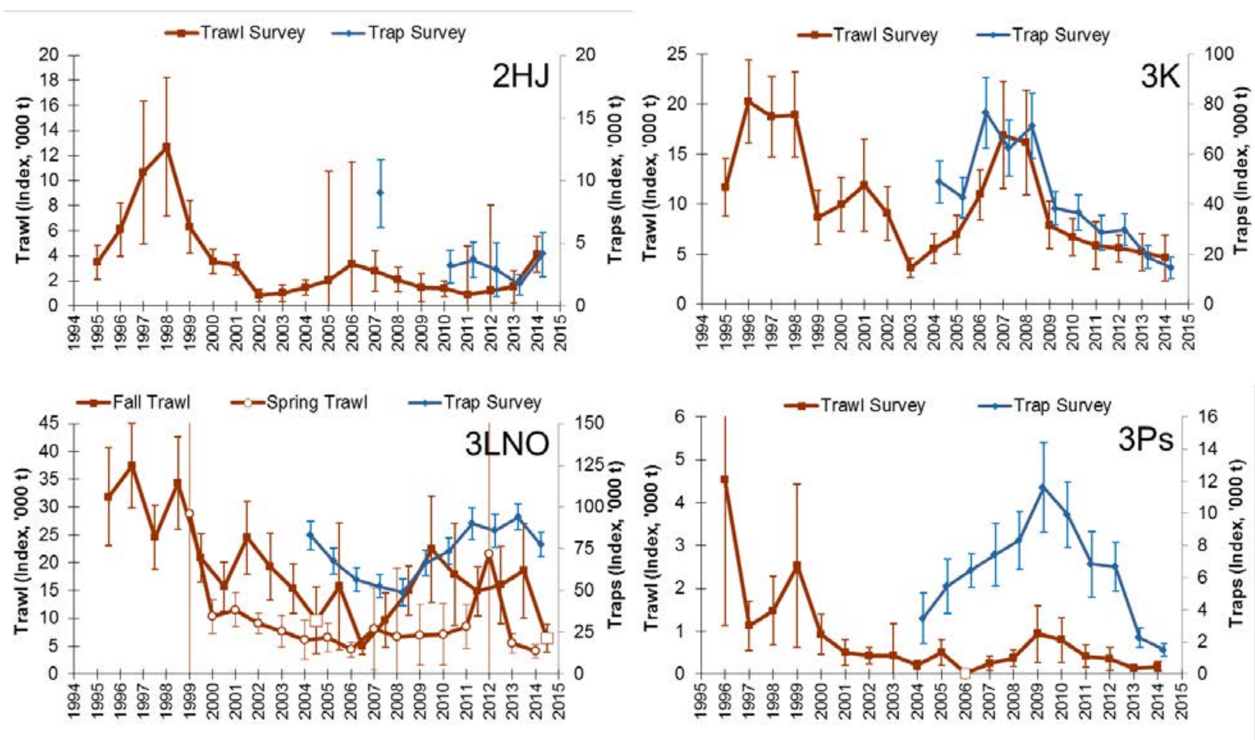


Figure 17: Trends in trawl survey exploitable biomass indices and the CPS trap survey exploitable biomass indices for offshore assessment divisions.

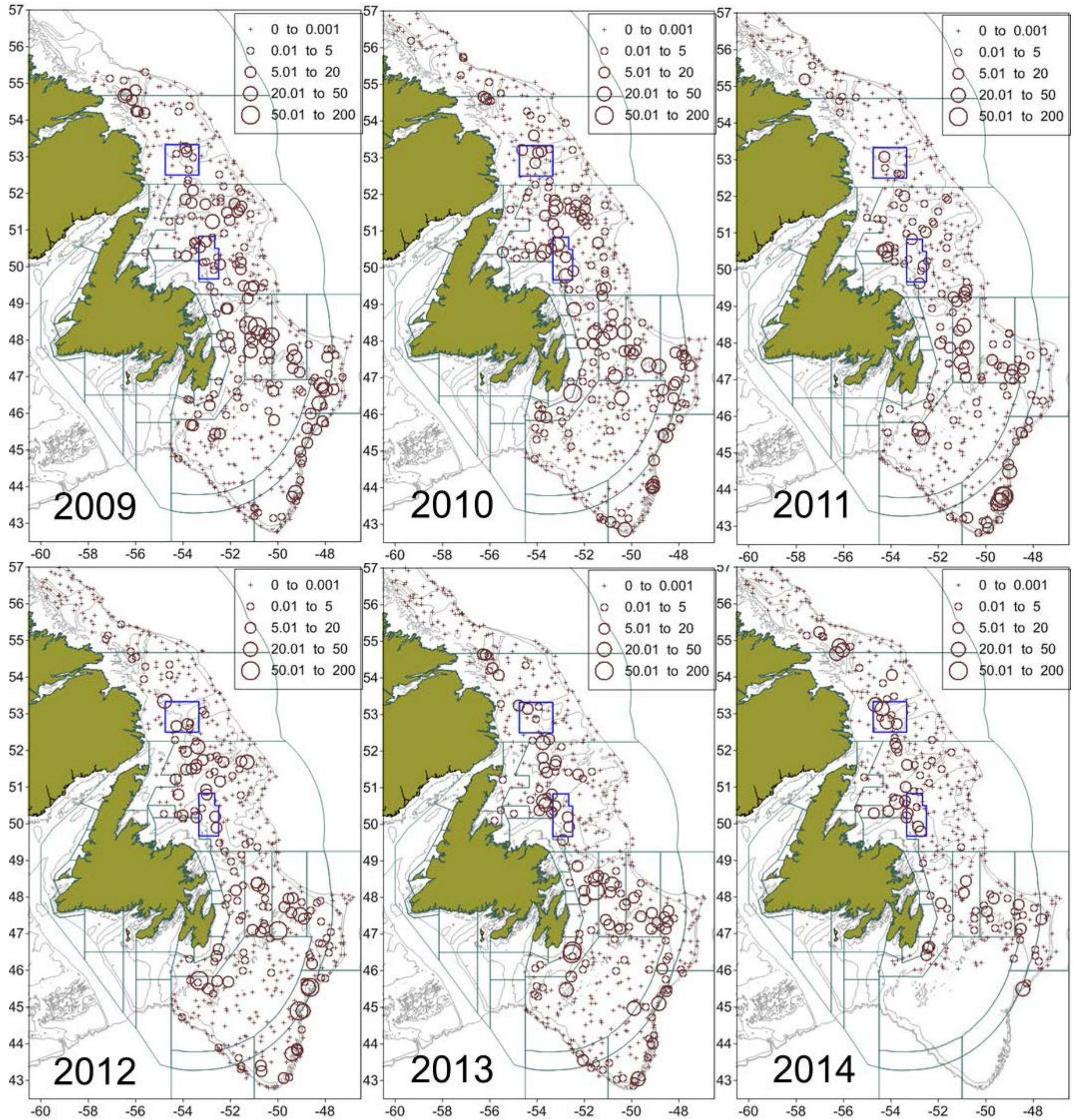


Figure 18: Distribution of exploitable males (> 94 mm CW adults) from Divs. 2HJ3KLNO fall bottom trawl surveys from 2009-14.

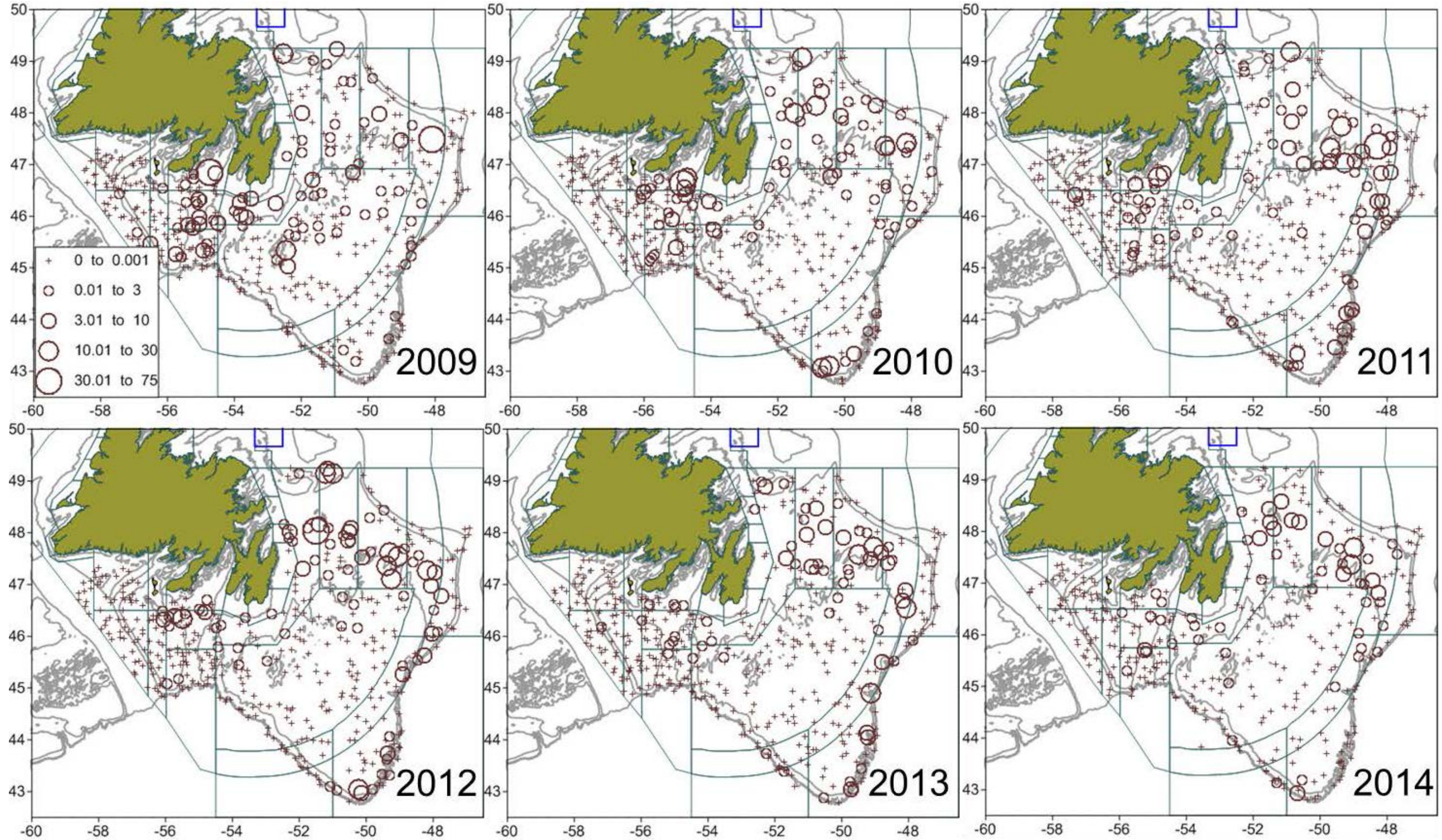


Figure 19: Distribution of exploitable males (> 94 mm CW adults) from Divs. 3LNOPs spring bottom trawl surveys from 2009-14.

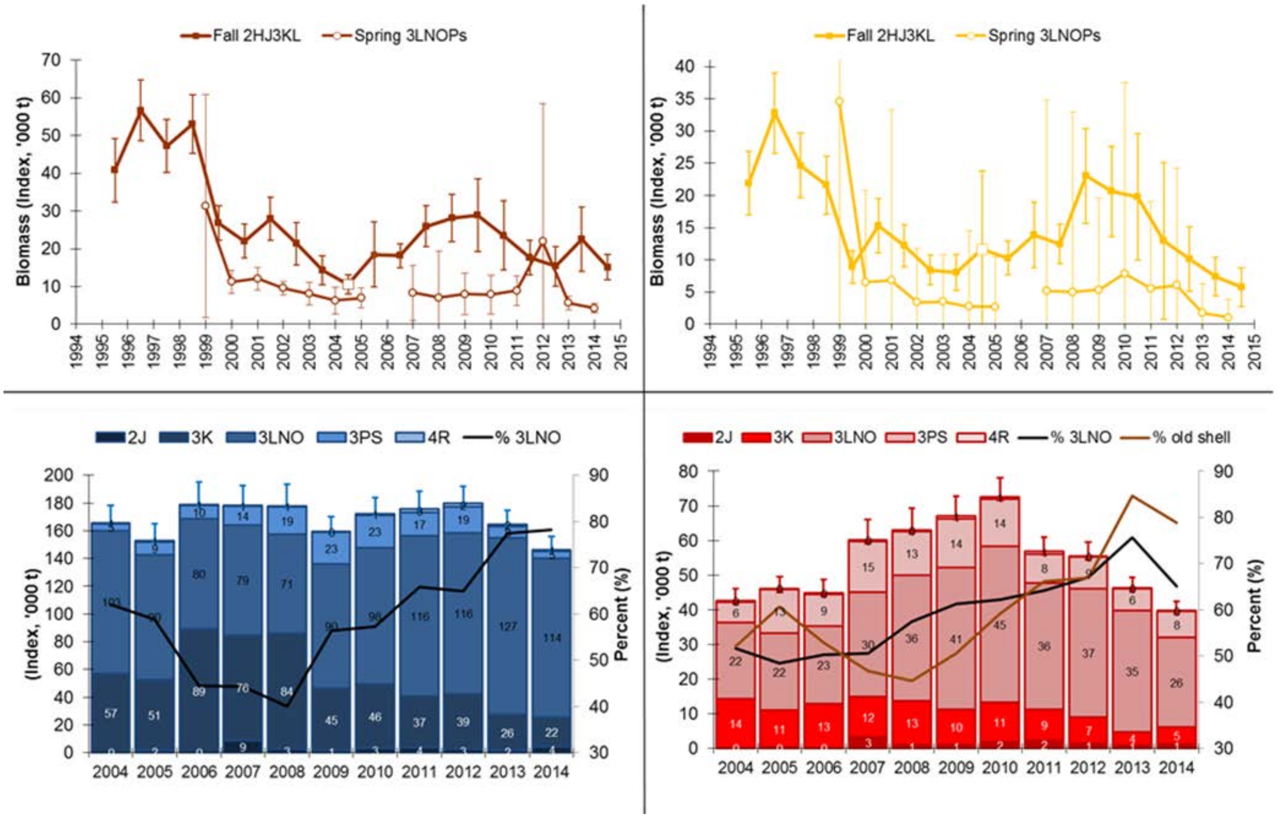


Figure 20: Trends in exploitable biomass indices (left) and pre-recruit biomass indices (right) from multi-species offshore surveys during fall (Divs. 2HJ3KL) and spring (Divs. 3LNOPs) (above) and from fall post-season trap surveys throughout inshore and offshore Divs. 2J3KLNOPs4R (below). The heavy line overlain on the trap-based indices represents the percentage of the index derived from Divs. 3LNO whereas the lighter line represents the percentage of sub-legal-sized crabs that were old-shelled.

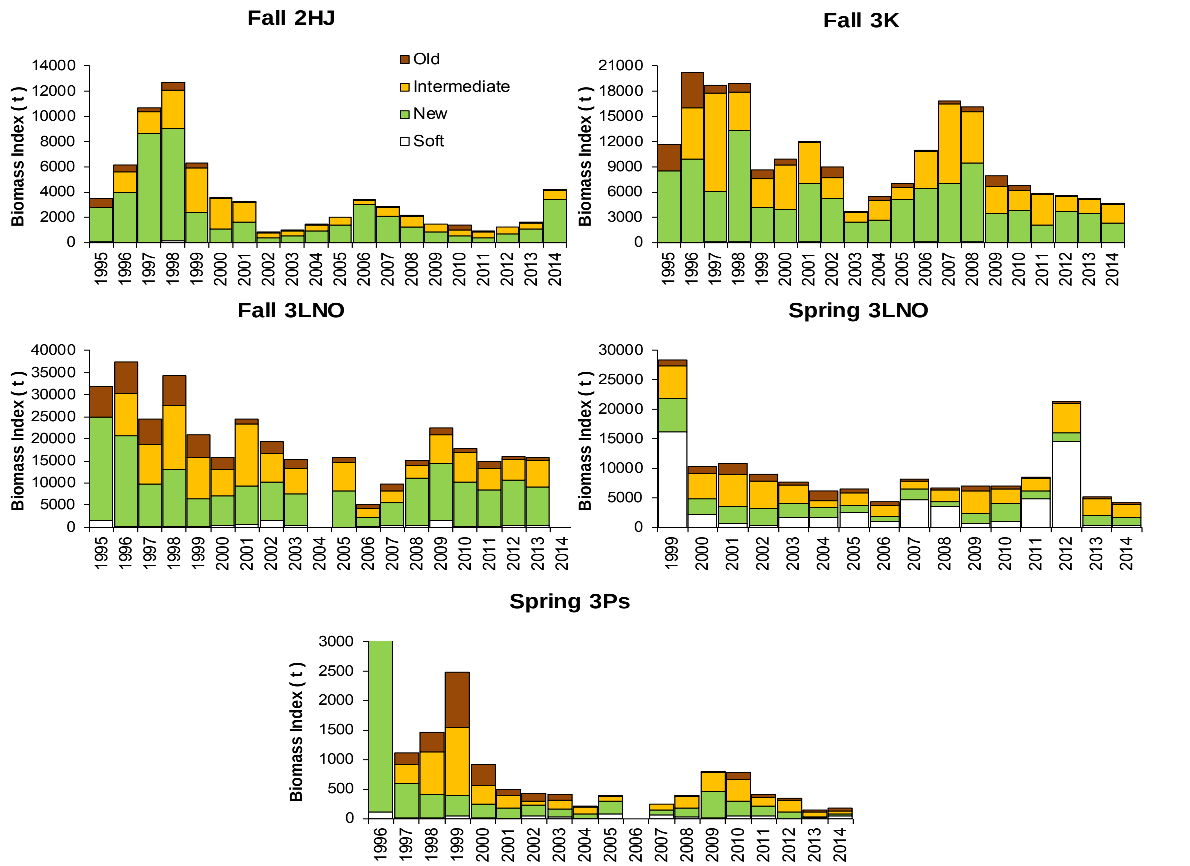


Figure 21: Trends in trawl survey exploitable biomass indices by shell condition for offshore assessment divisions.

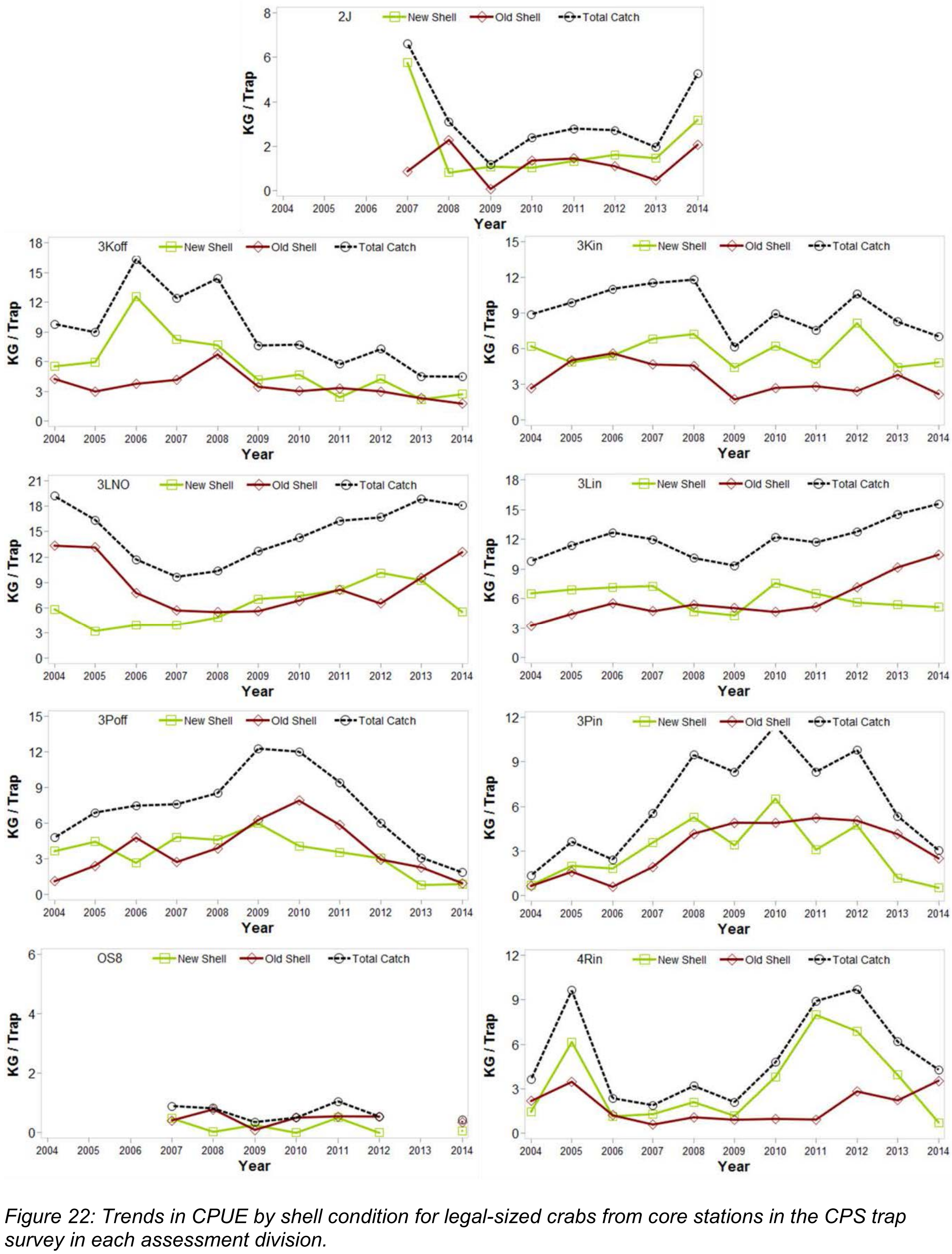


Figure 22: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in each assessment division.

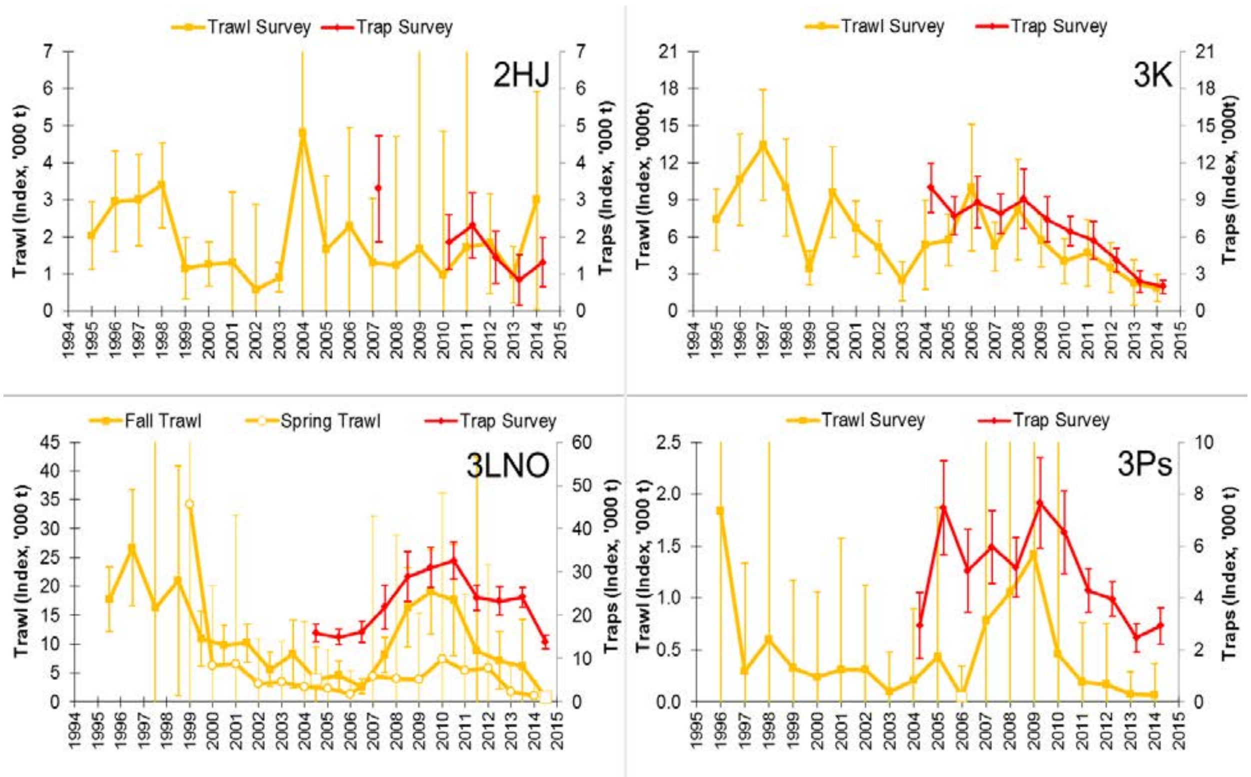


Figure 23: Trends in trawl survey pre-recruit biomass indices and the CPS trap survey pre-recruit biomass indices for offshore assessment divisions.

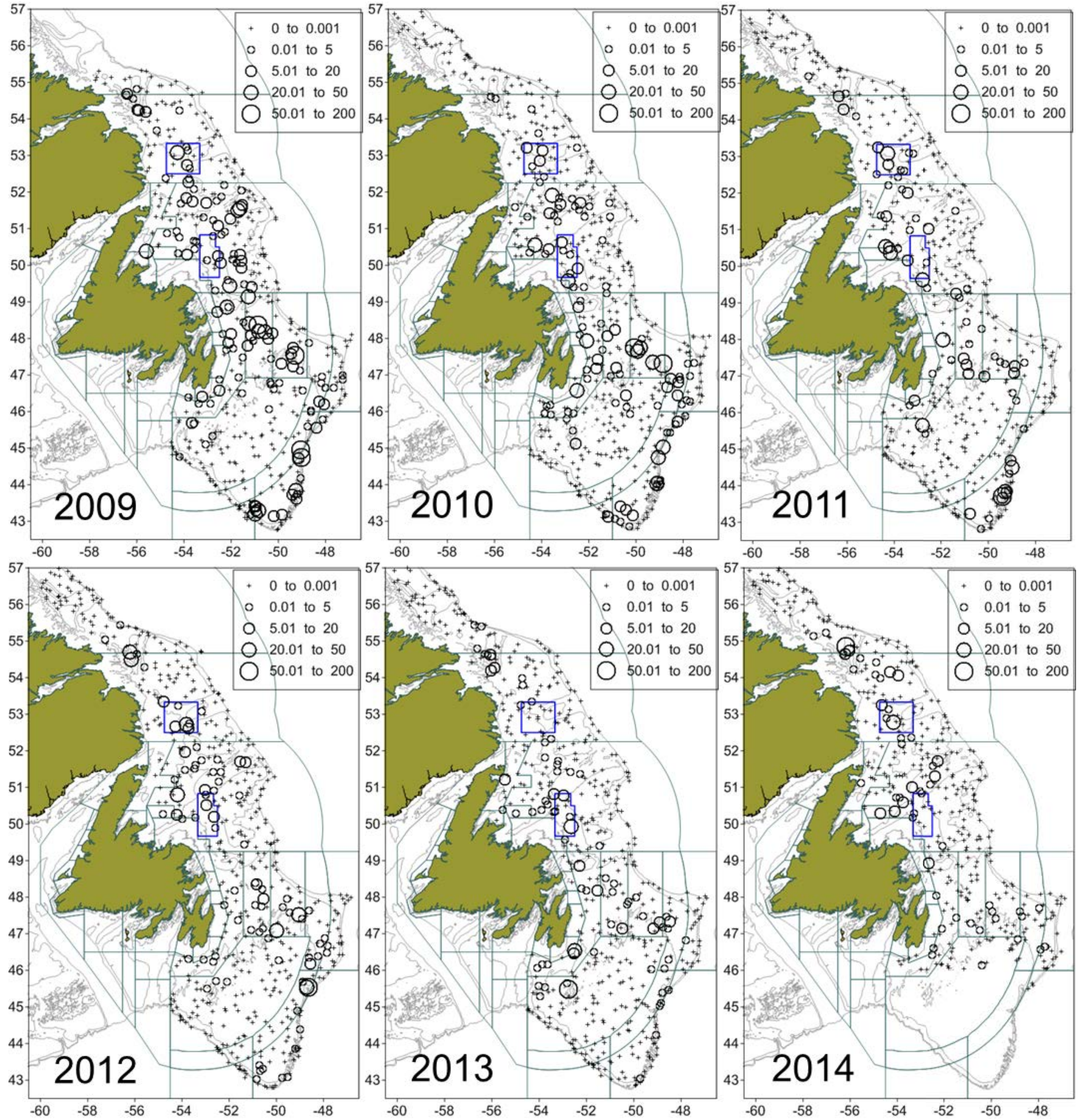


Figure 24: Distribution of pre-recruit males (> 75 mm CW adolescents) from Divs. 2HJ3KLNO fall bottom trawl surveys from 2009-14.

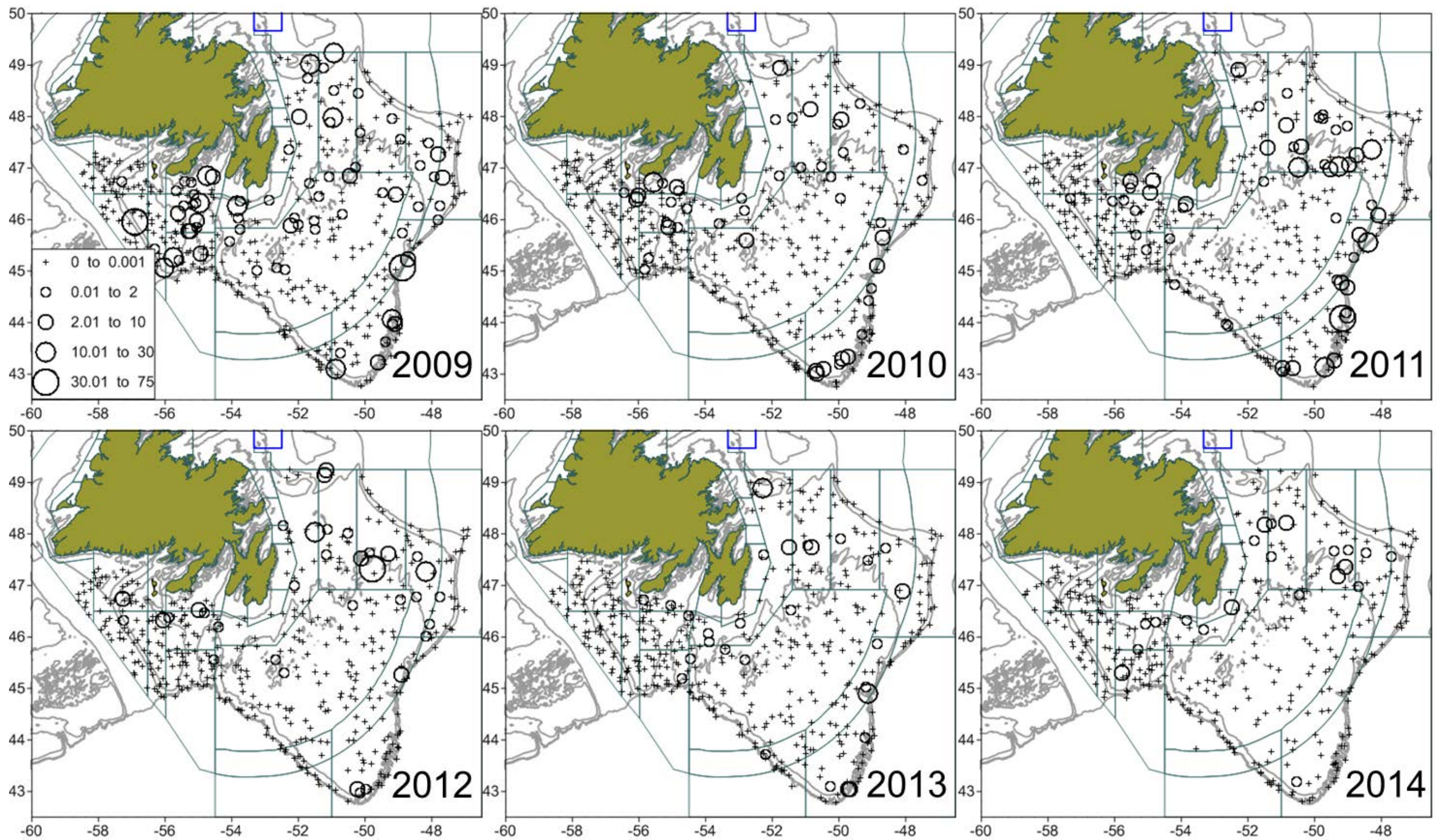


Figure 25: Distribution of pre-recruit males (> 75 mm CW adolescents) from Divs. 3LNOPs spring bottom trawl surveys from 2009-14.

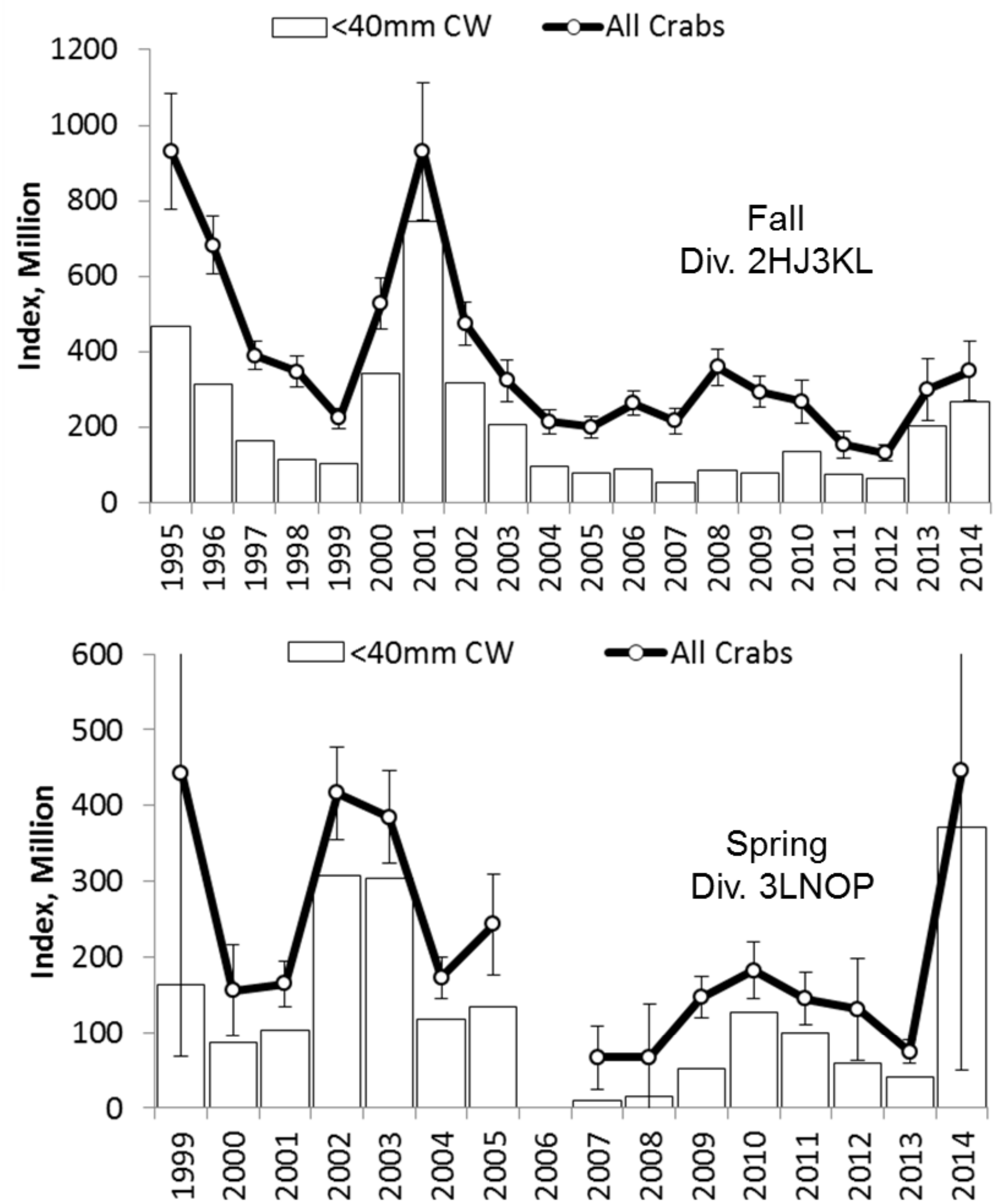


Figure 26: Trends in abundance (index) of all crabs as well as small (< 40 mm CW) crabs captured in fall Divs. 2J3KLNO trawl surveys (top panel) and spring Divs. 3LNOPs trawl surveys (bottom panel).

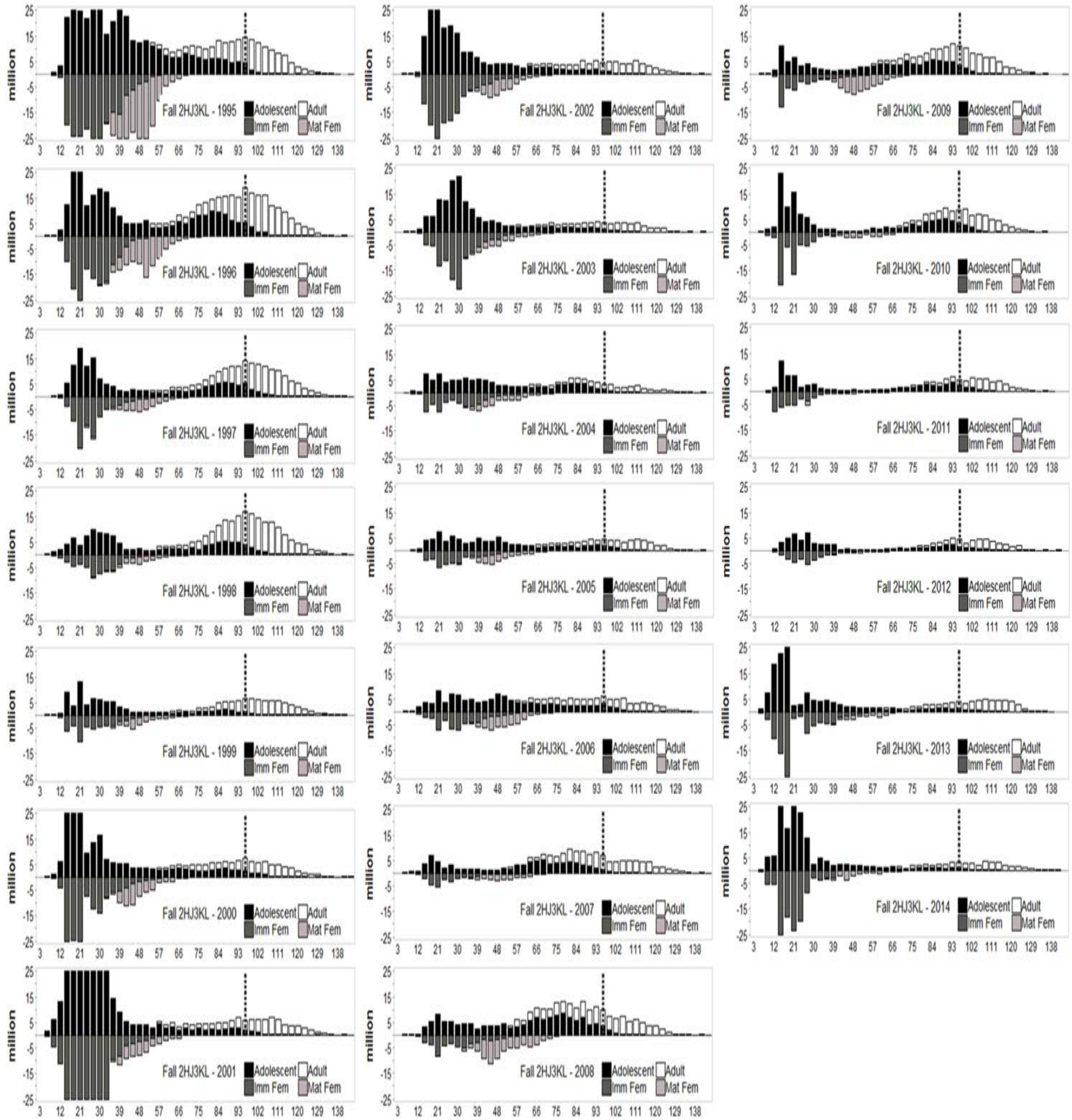


Figure 27: Annual abundance indices since 1995 by carapace width for Divs. 2J3KL juveniles plus adolescent males (dark bars), adult males (white bars), immature females (dark grey bars) and mature females (light grey bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line.

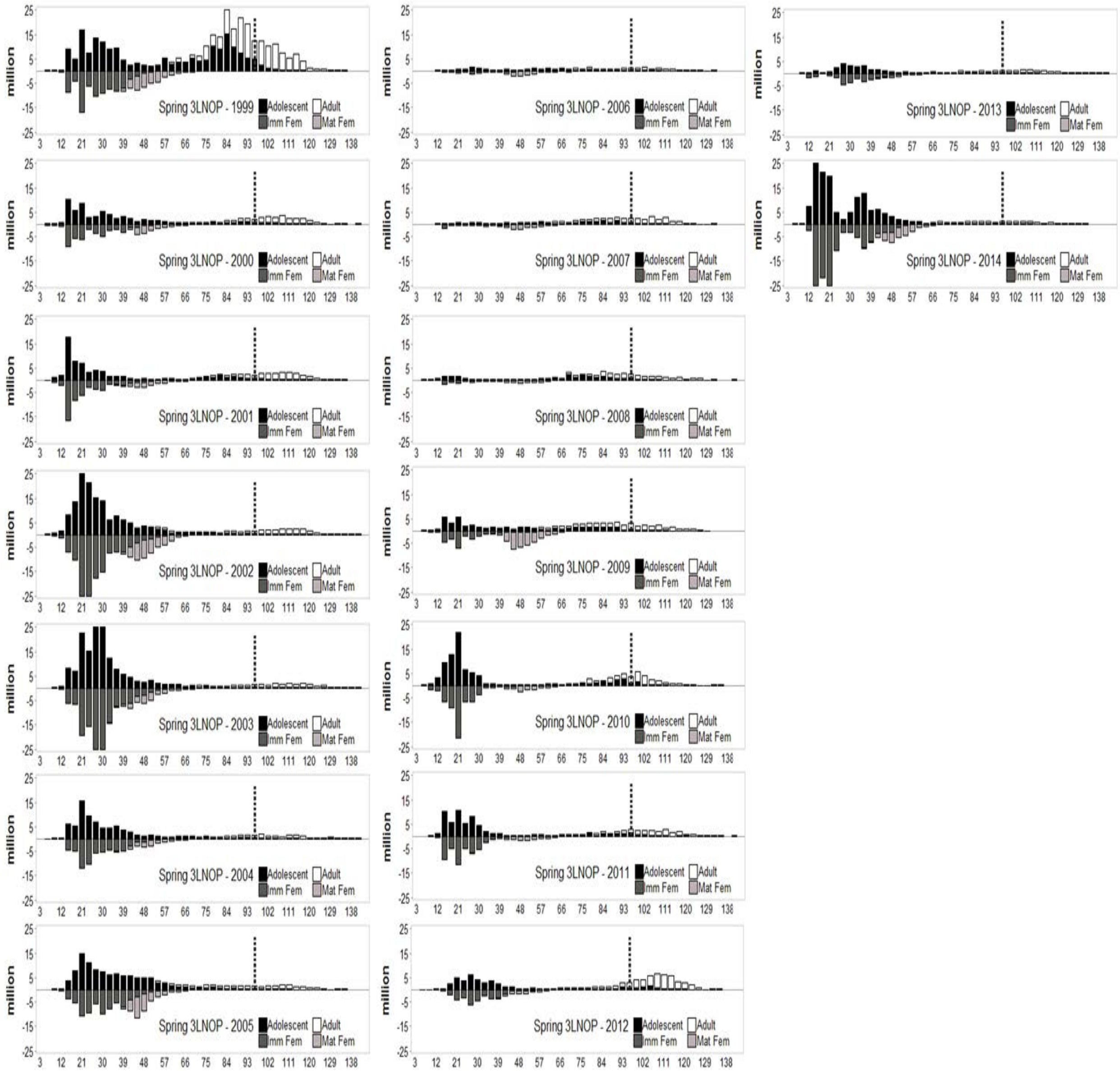


Figure 28: Annual abundance indices since 1999 by carapace width for Divs. 3LNOPs juveniles plus adolescent males (dark bars), adult males (white bars), immature females (dark grey bars) and mature females (light grey bars) from spring trawl surveys. Abundance is truncated for smallest crabs (< 50 mm CW). The minimum legal size is indicated by a vertical dashed line.

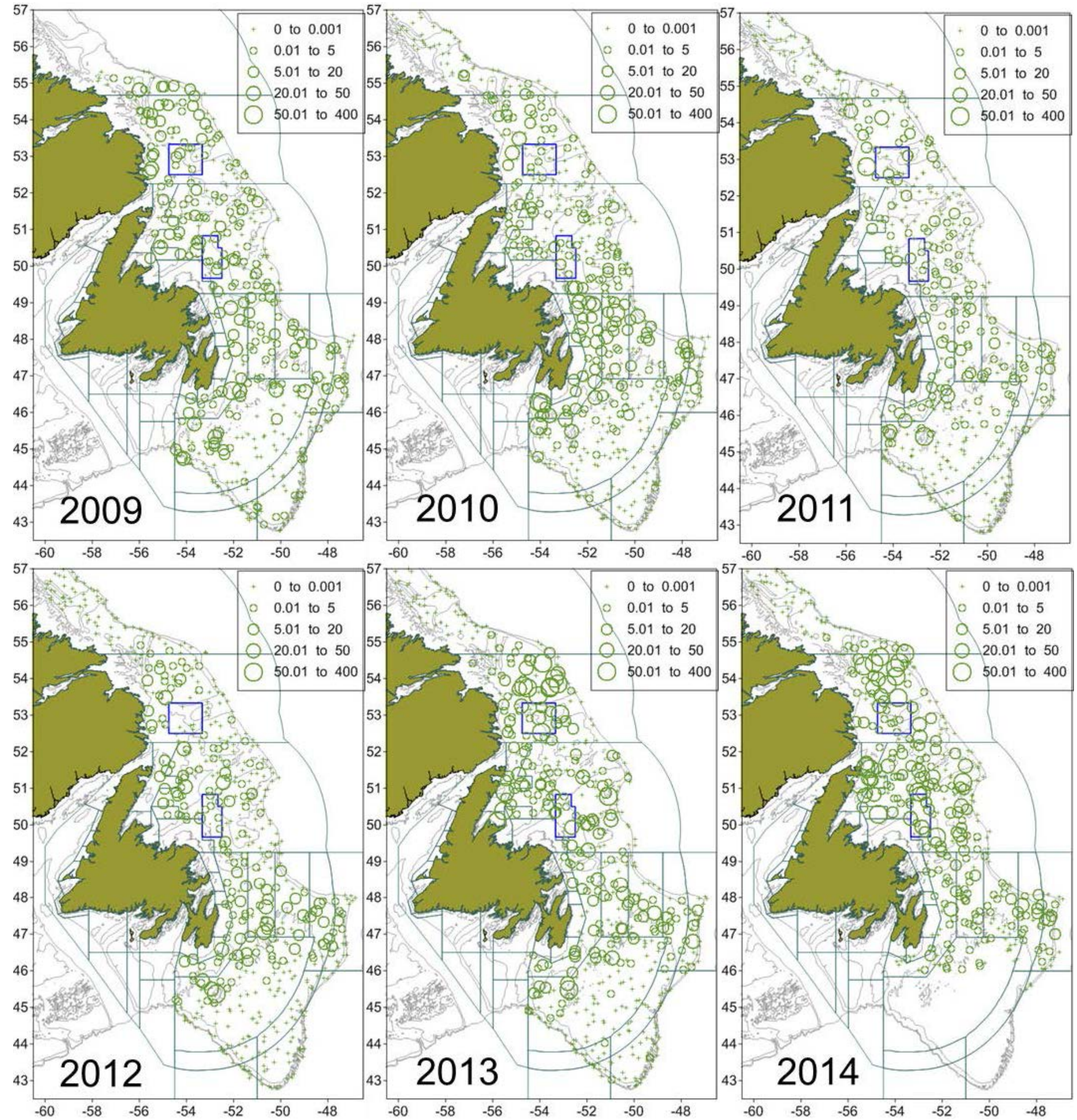


Figure 29: Distribution of small males (< 60 mm CW adolescents) from Divs. 2HJ3KLNO fall bottom trawl surveys from 2009-14.

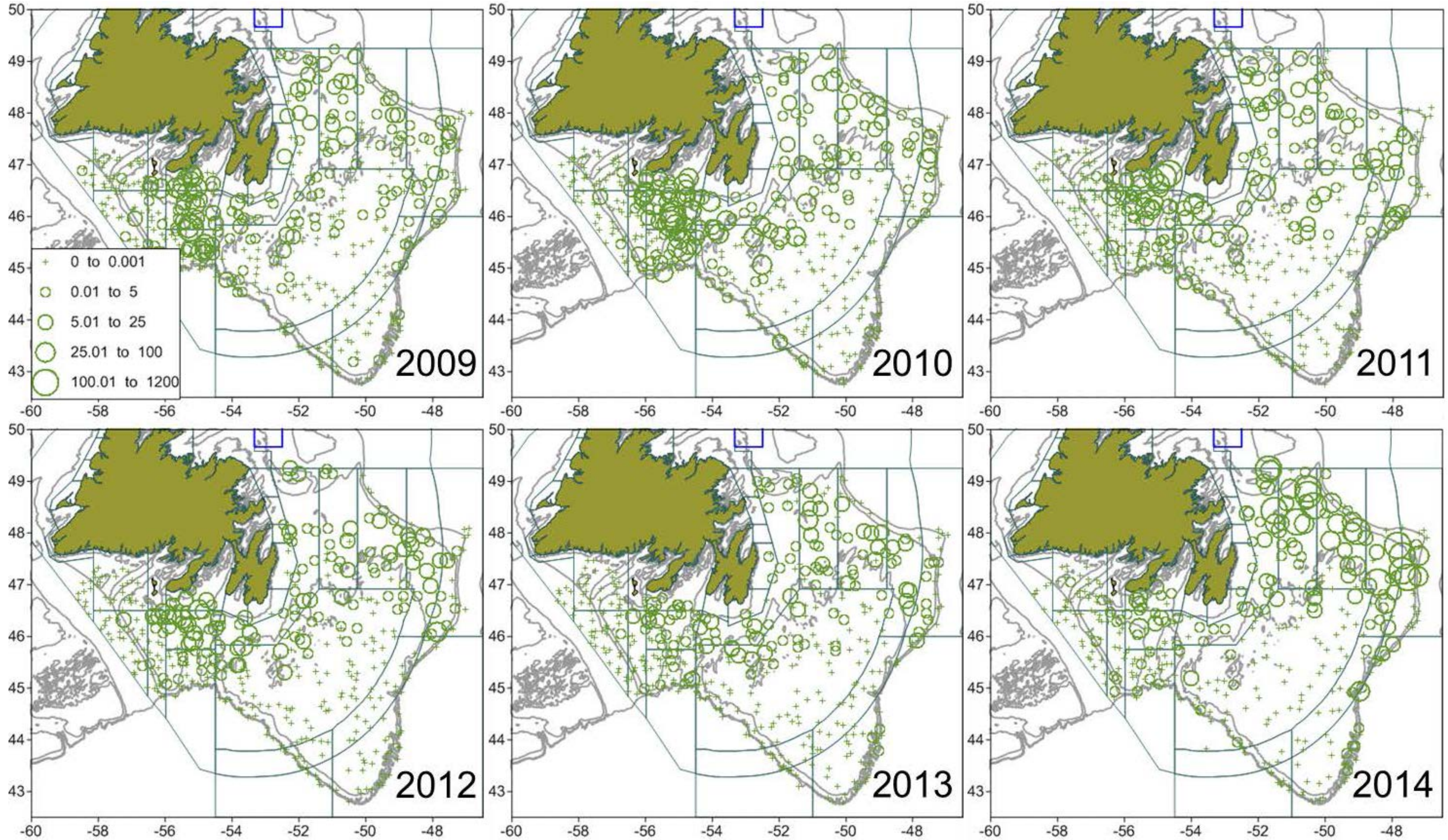


Figure 30: Distribution of pre-recruit males (< 60 mm CW adolescents) from Divs. 3LNOPs spring bottom trawl surveys from 2009-14.

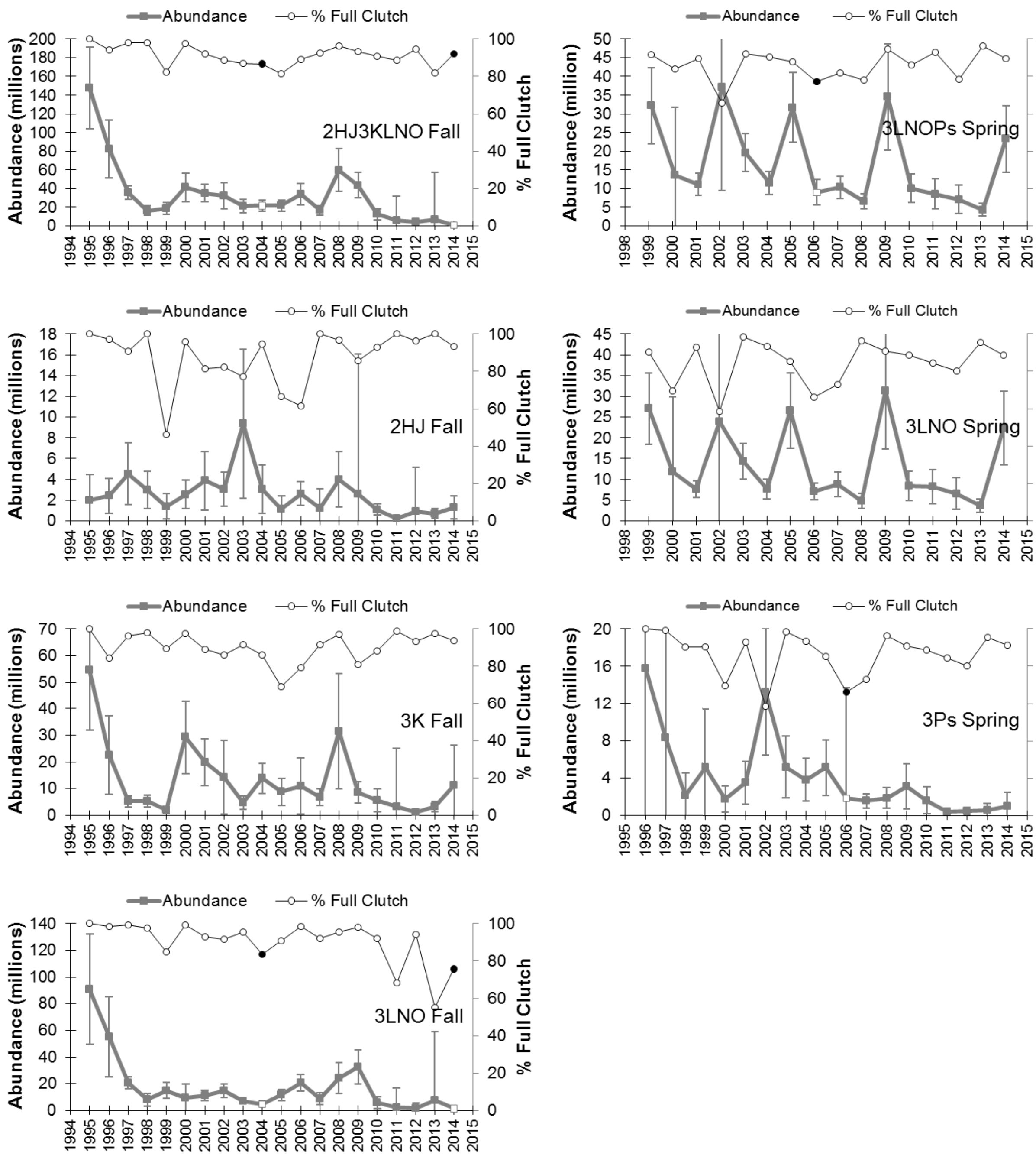


Figure 31: Trends in the mature female abundance index and percentage of mature females bearing full clutches of viable eggs in fall trawl surveys (left panels) and spring trawl surveys (right panels) for offshore assessment divisions. Open symbols on the abundance index and solid symbols on the egg clutch index depict incomplete surveys.

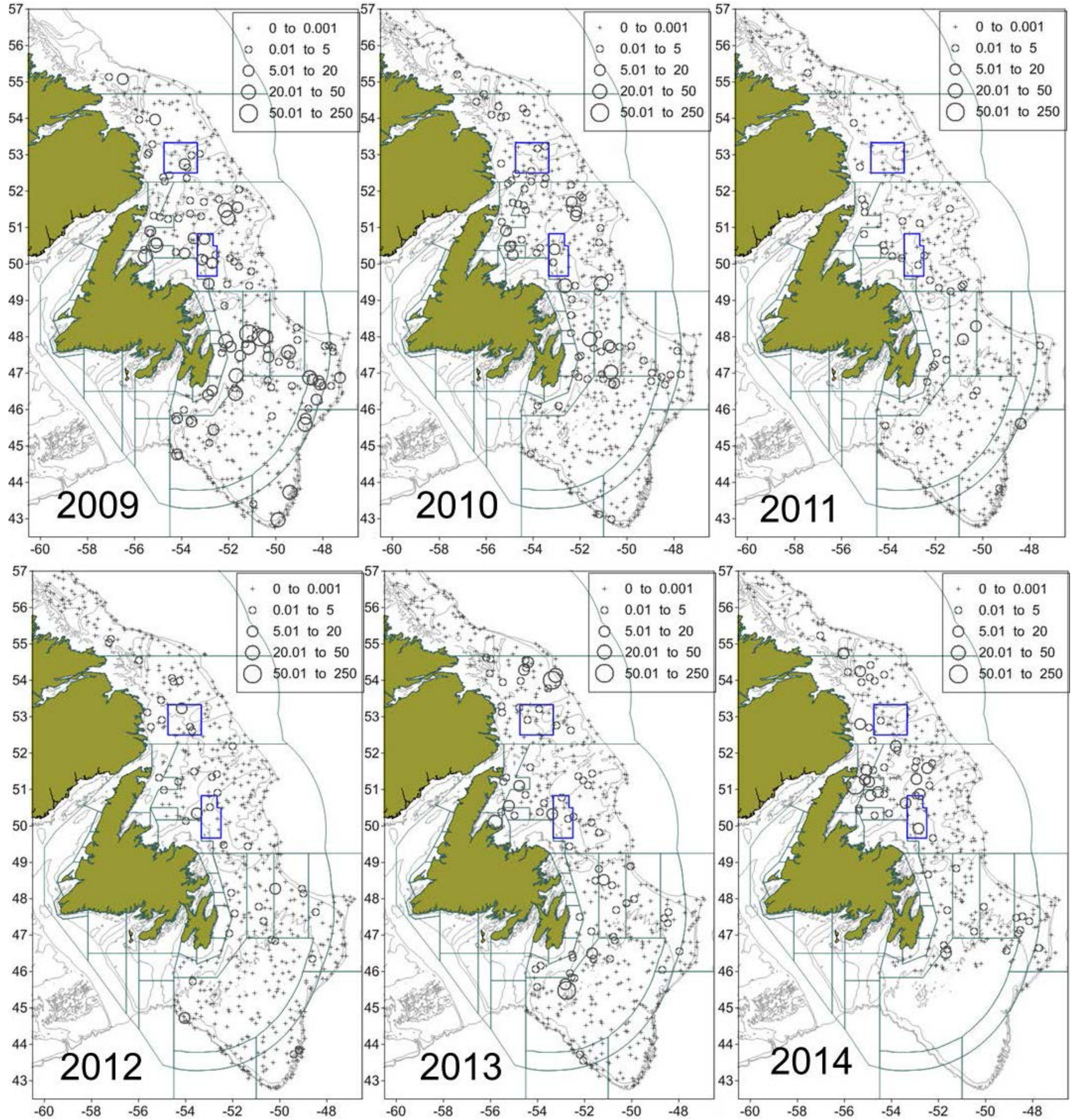


Figure 32: Distribution of mature females from Divs. 2HJ3KLNO fall bottom trawl surveys from 2009-14.

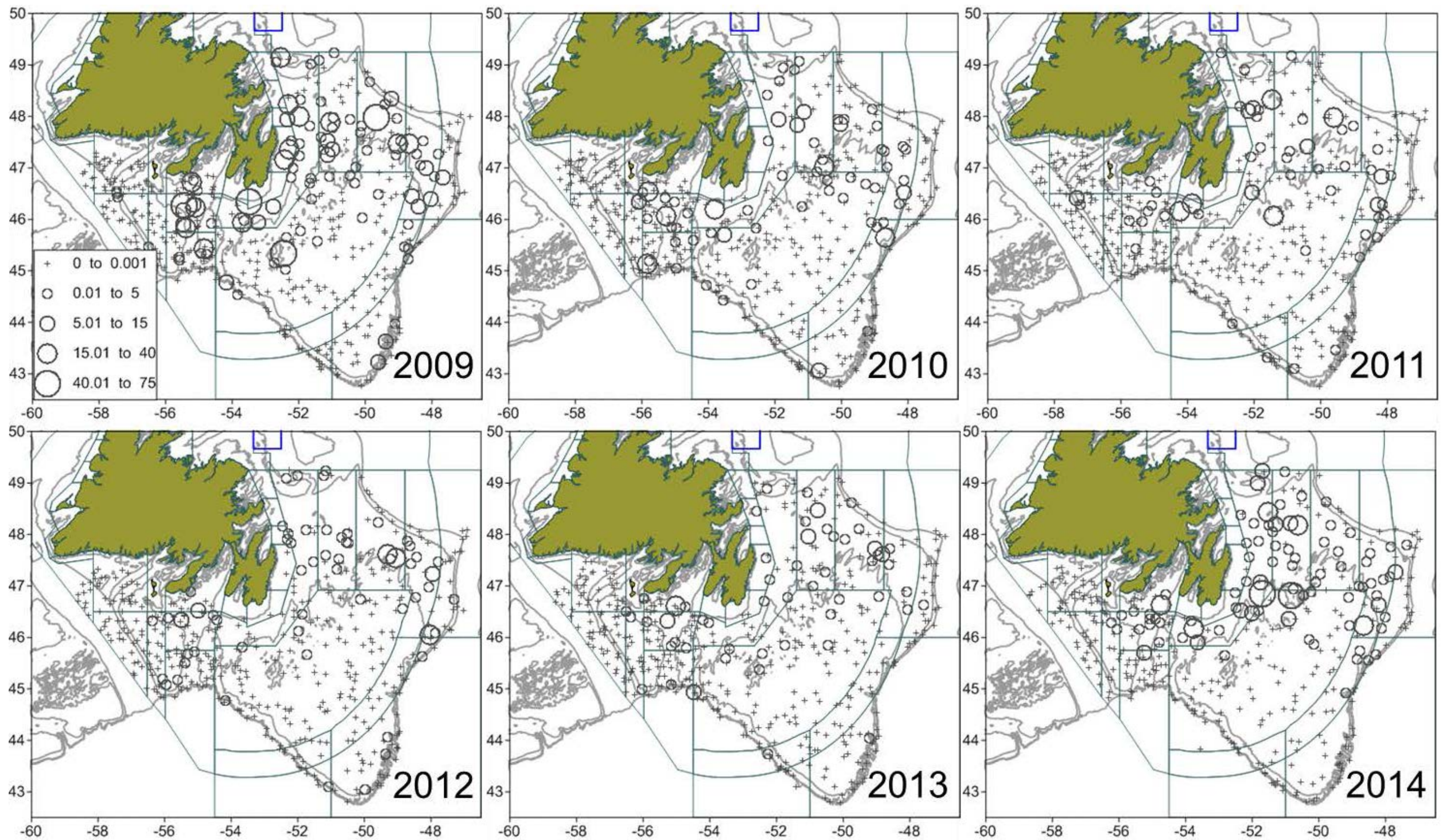


Figure 33: Distribution of mature females from Divs. 3LNOPs spring bottom trawl surveys from 2009-14.

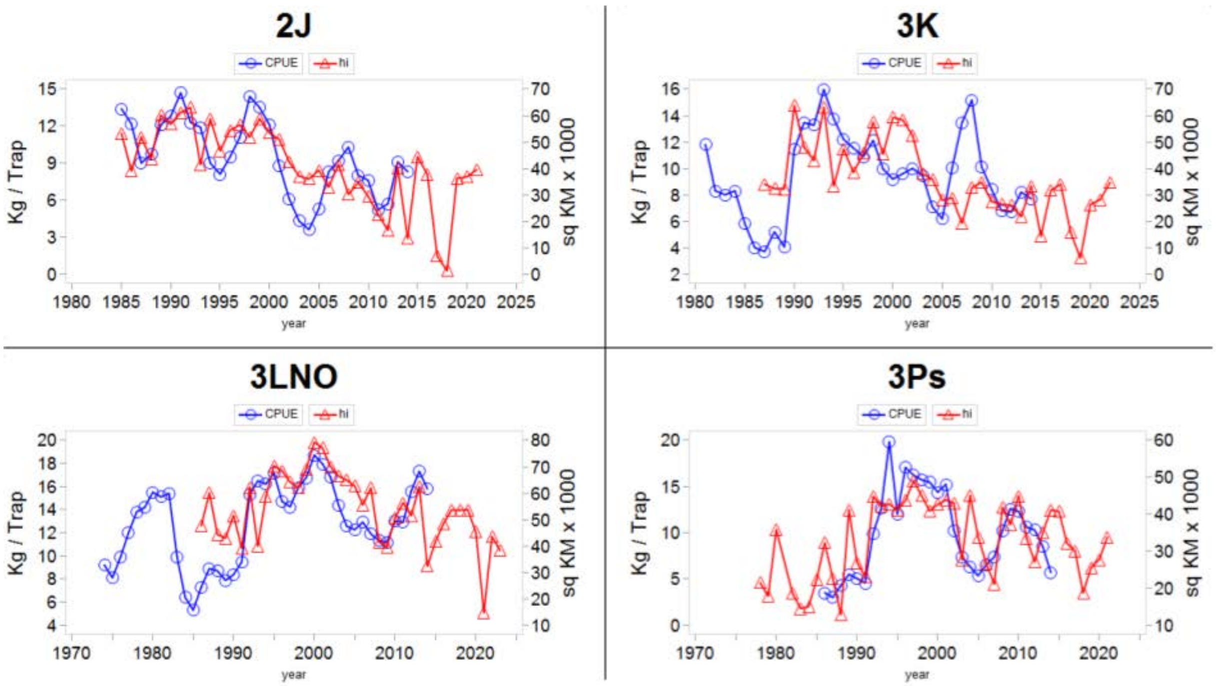


Figure 34. Relationship of CPUE with habitat indices (HI) for Divs. 2J3KLNOPs at delays of 7-8 years for Divs. 2J3KPs and 10 years for Divs. 3LNO. Delay of best fit was determined by pairwise correlation analysis.

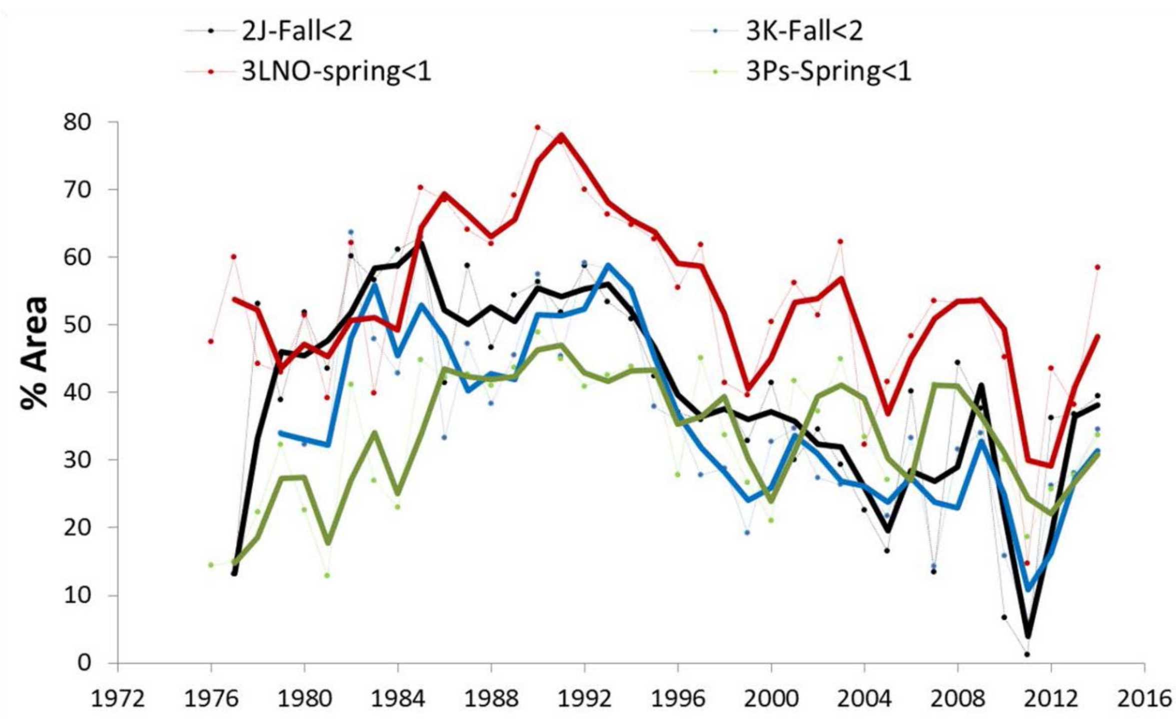


Figure 35: Snow Crab thermal habitat indices. Thick lines show two-year running averages.

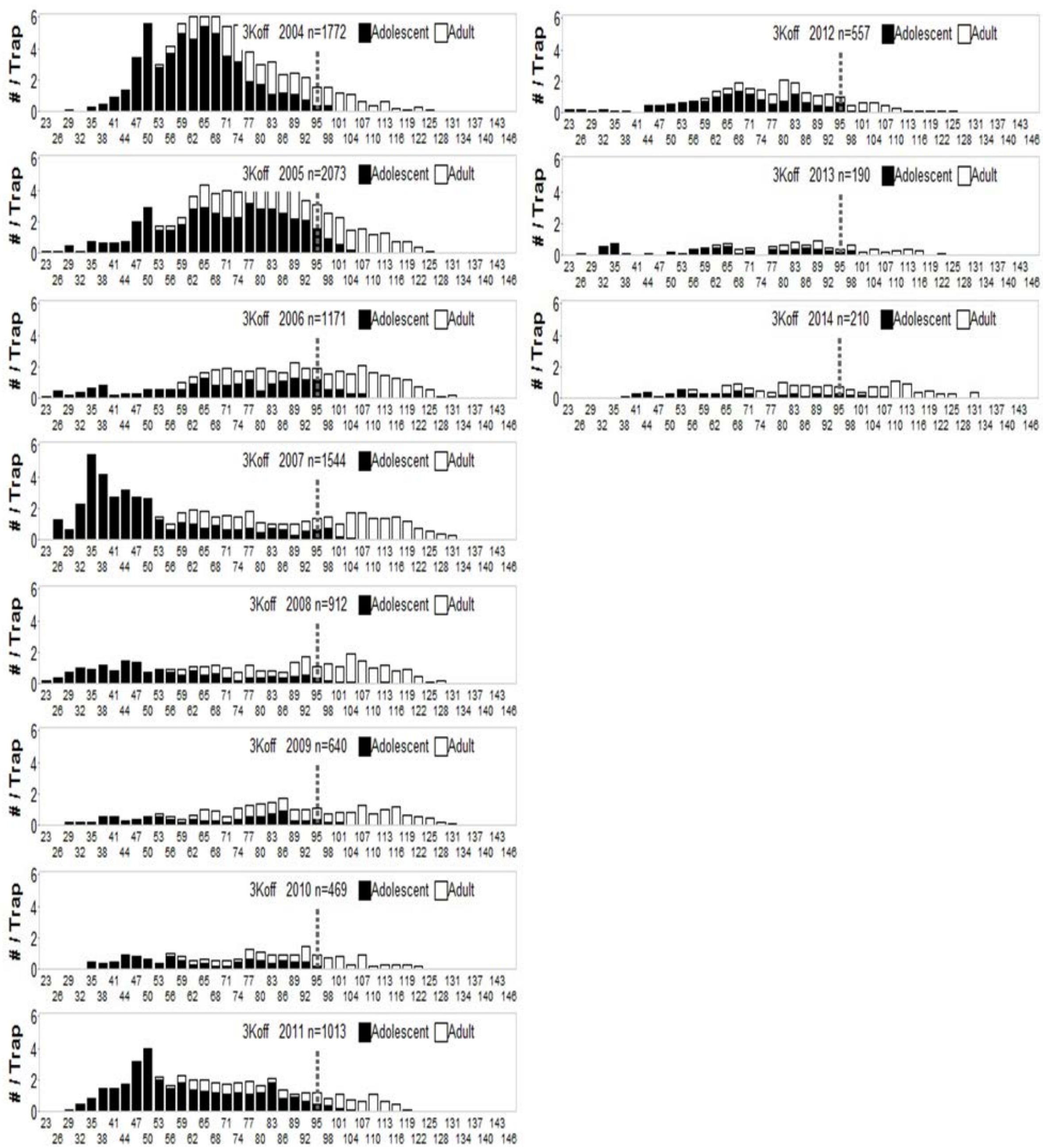


Figure 36: Trends in male carapace width distributions from small-mesh traps in the Div. 3K offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

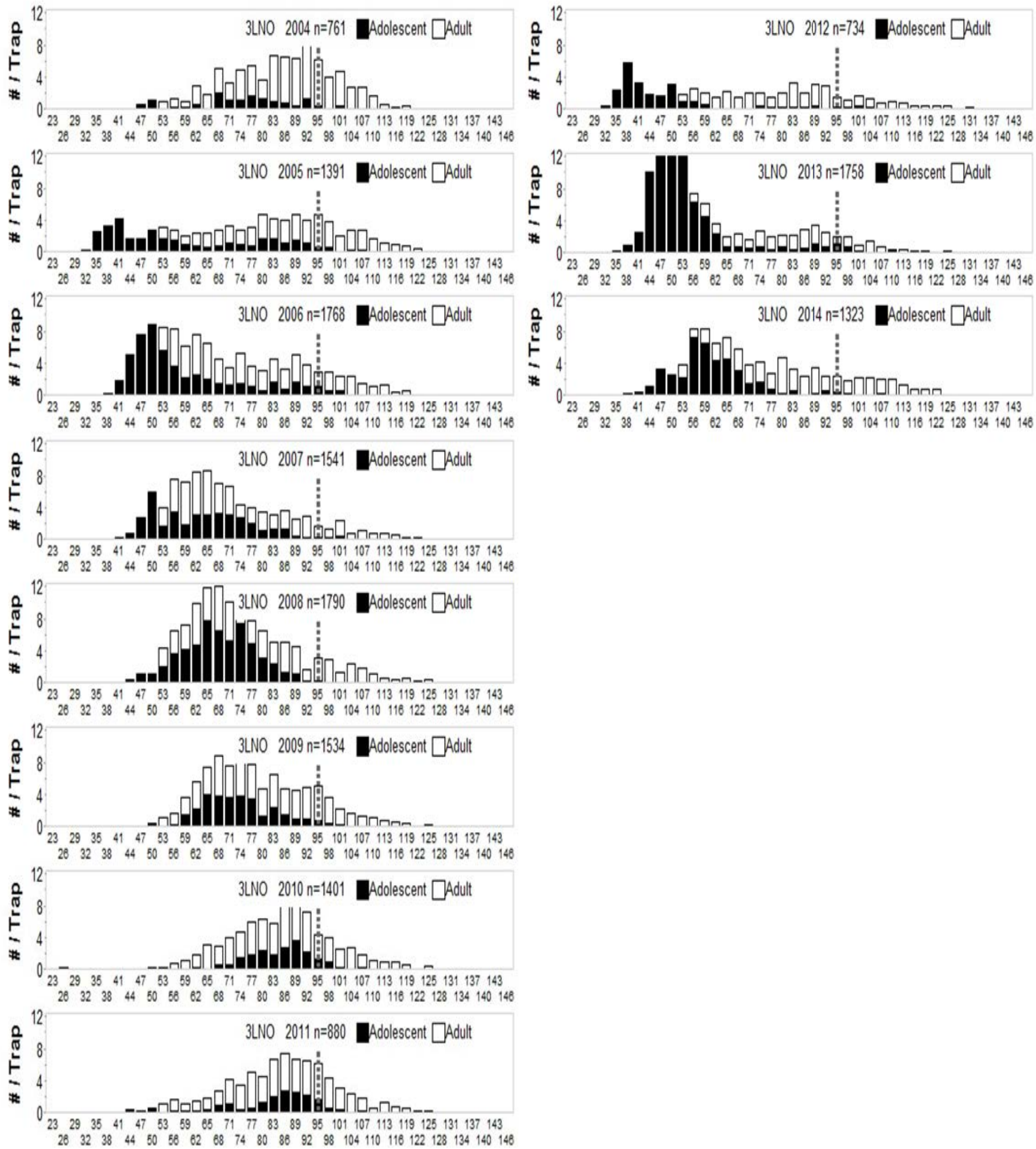


Figure 37: Trends in male carapace width distributions from small-mesh traps in the Divs. 3LNO offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

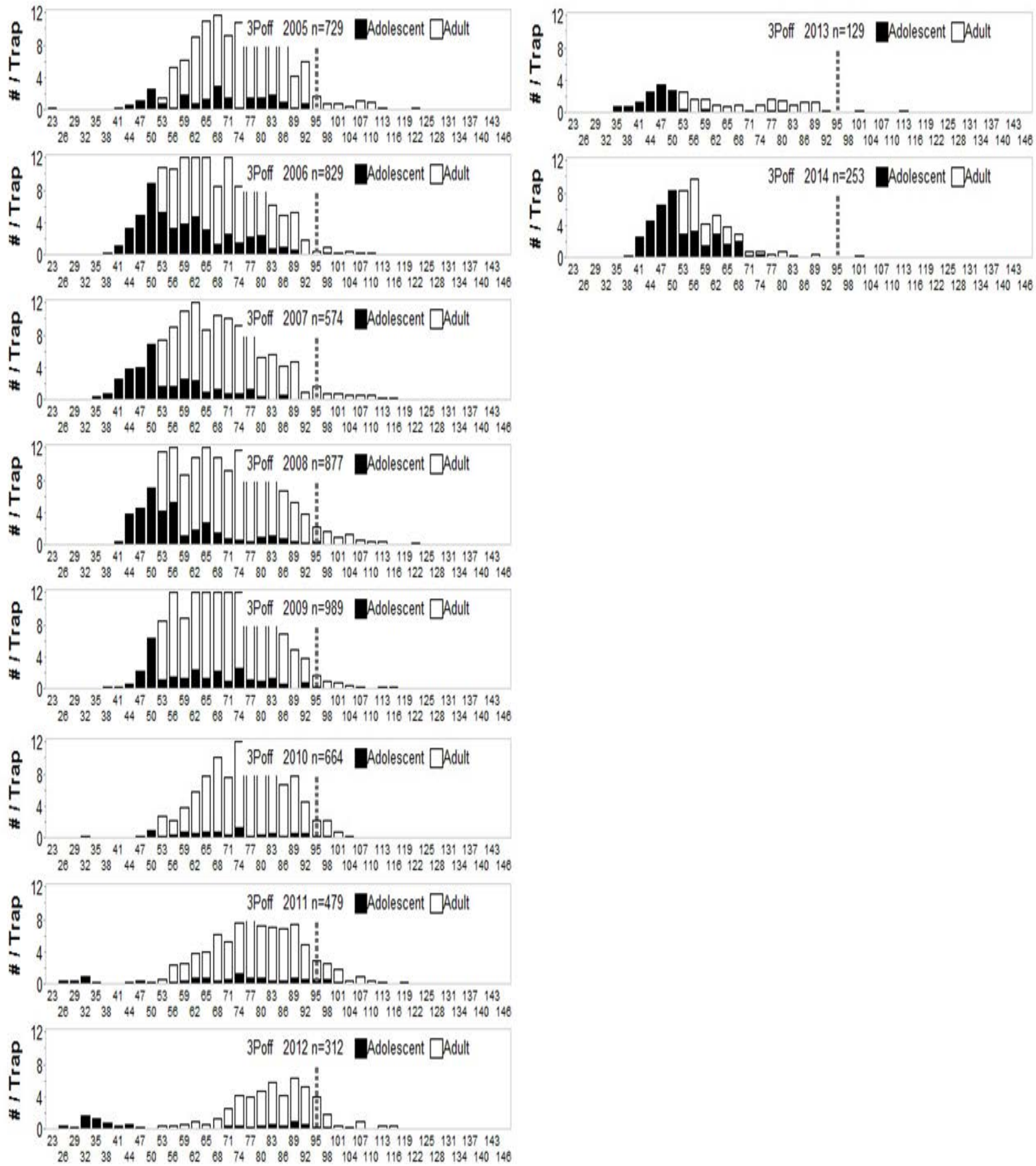


Figure 38: Trends in male carapace width distributions from small-mesh traps in the Divs. 3LNO offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

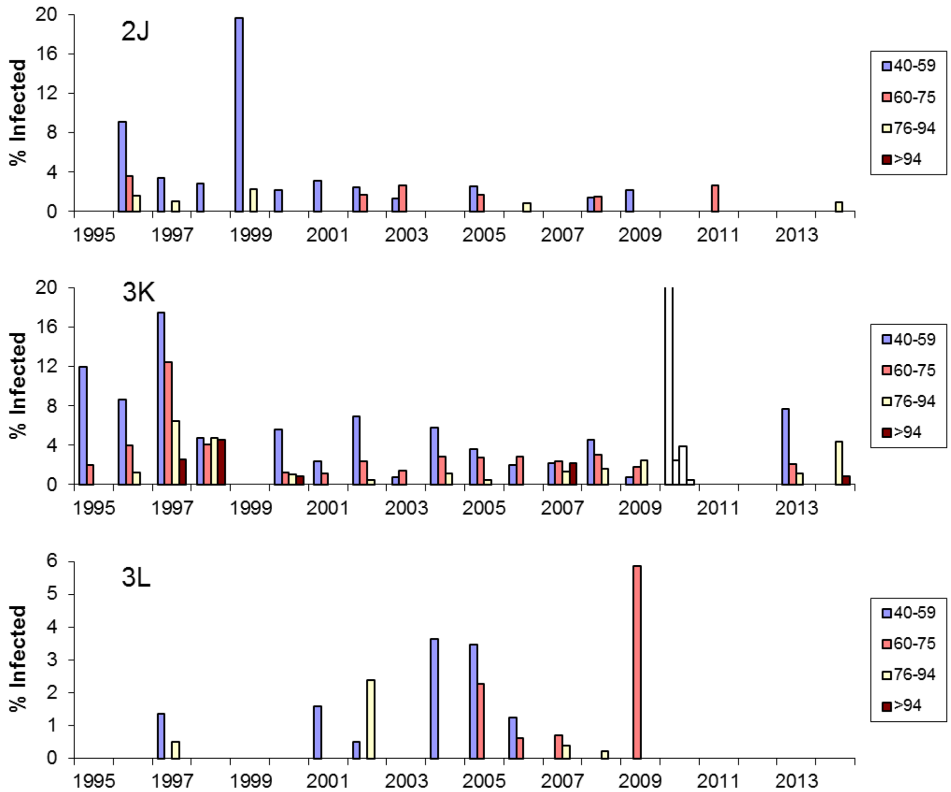


Figure 39: Annual trends in prevalence of BCD in new-shelled adolescent males by size group from fall trawl surveys in offshore assessment divisions.

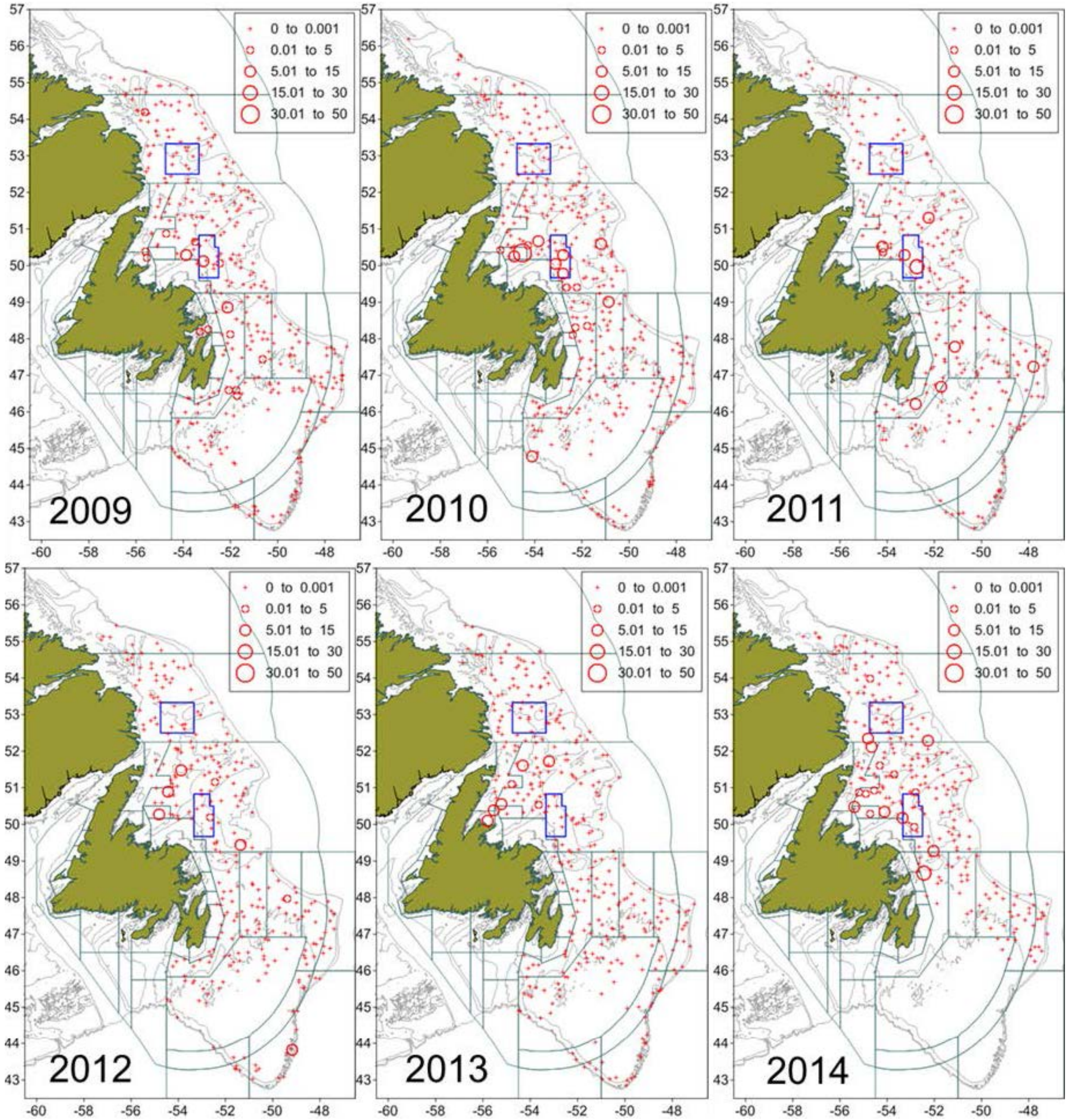


Figure 40: Percentage of male crabs with BCD from Divs. 2HJ3KLNO fall bottom trawl surveys from 2009-14.

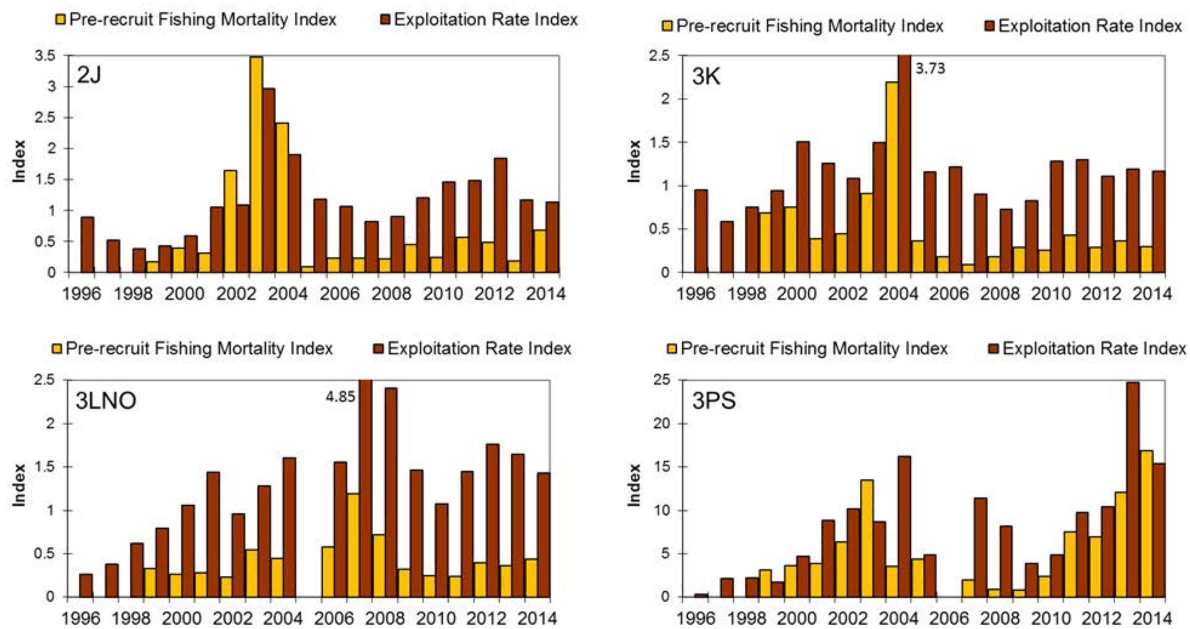


Figure 41: Trends in mortality indices (the exploitation rate index and the pre-recruit fishing mortality rate index) for offshore assessment divisions.

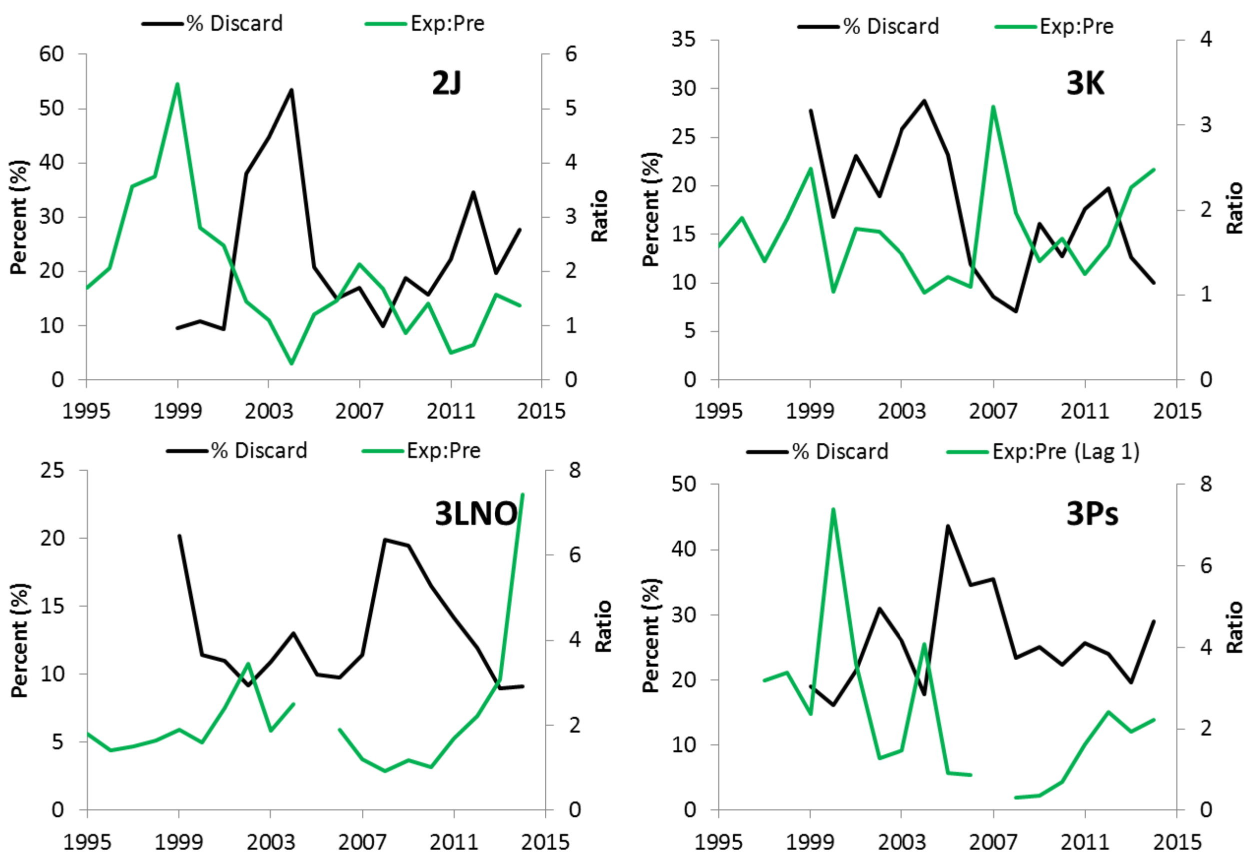


Figure 42: Trends in the ratio of exploitable to pre-recruit biomass indices from trawl surveys in relation to the observed percentage of the catch discarded in the fishery in offshore assessment divisions.

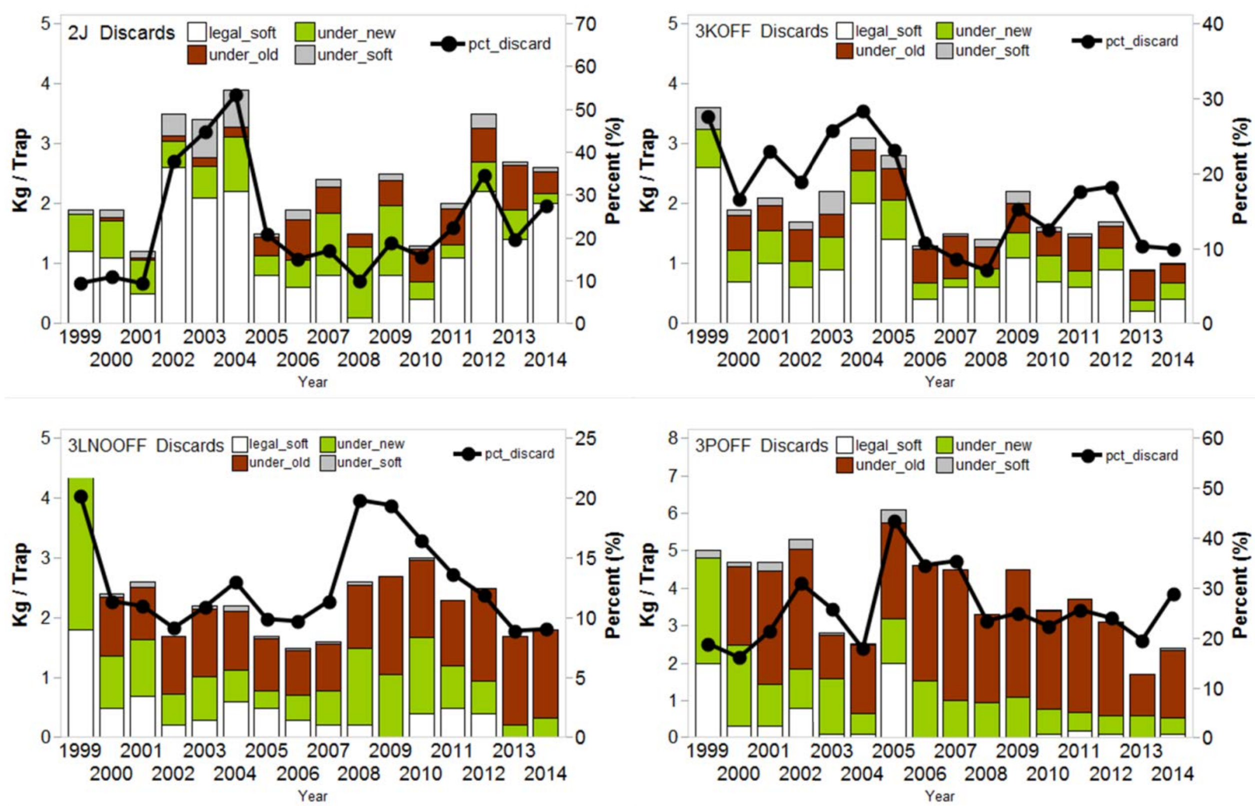


Figure 43: Trends in observed catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded, in offshore assessment divisions.

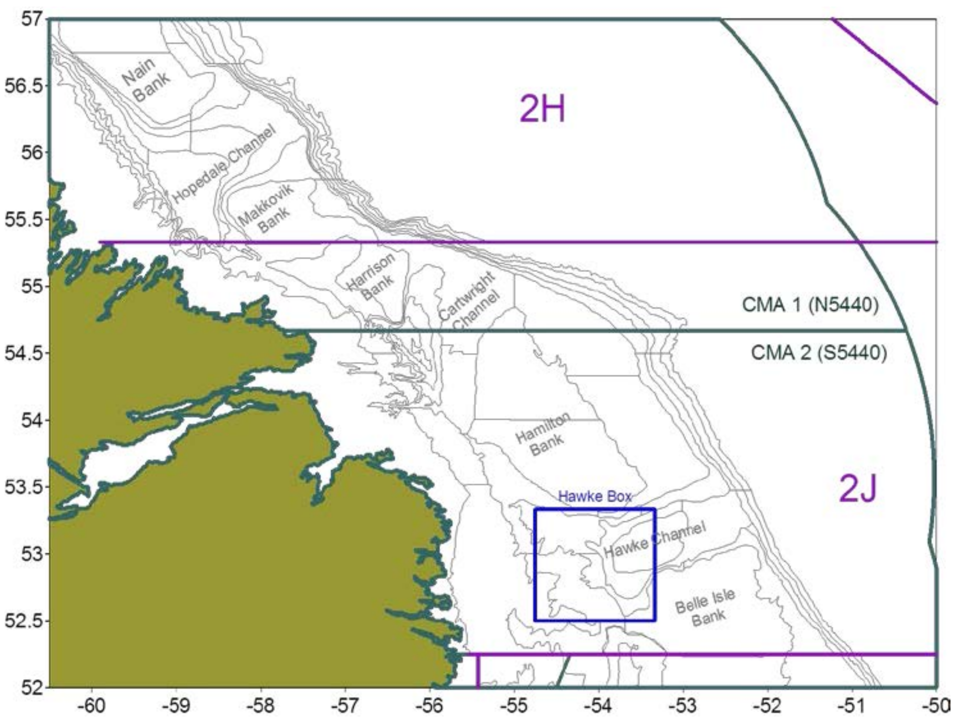


Figure 44: Map of Divs. 2HJ showing important bathymetric features and the Hawke Channel closed area.

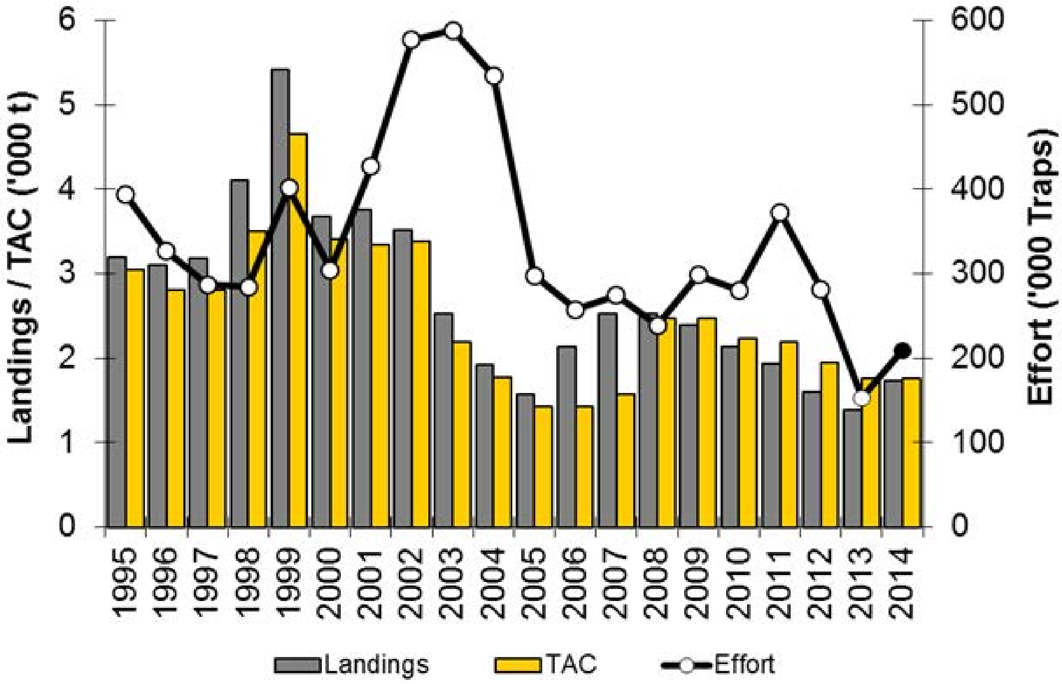


Figure 45: Trends in Divs. 2HJ landings, TAC, and fishing effort. 2014 effort preliminary.

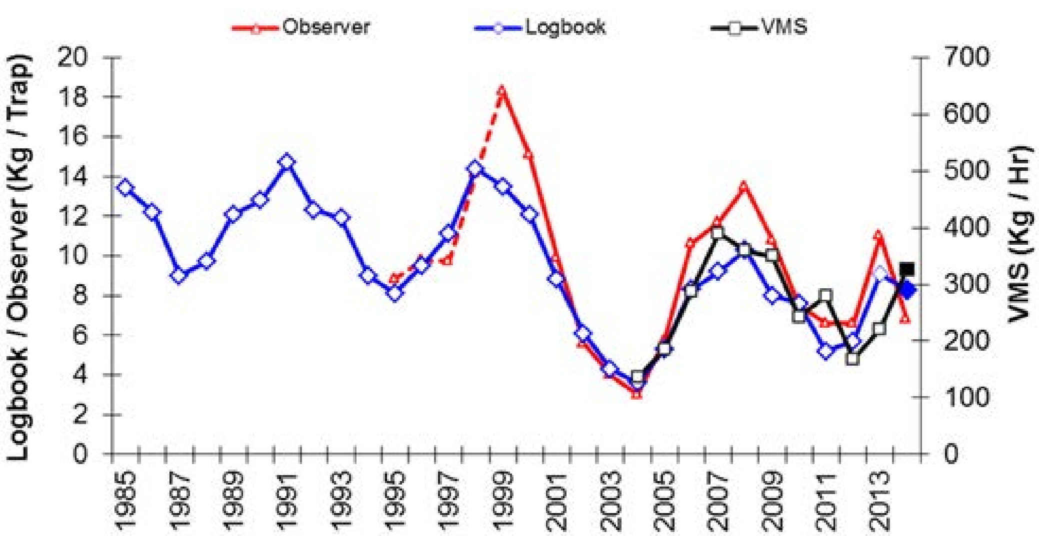


Figure 46: Trends in commercial logbook-based, observer-based, and VMS-based CPUE in the Divs. 2HJ fishery. 2013 logbook and VMS CPUE estimates preliminary.

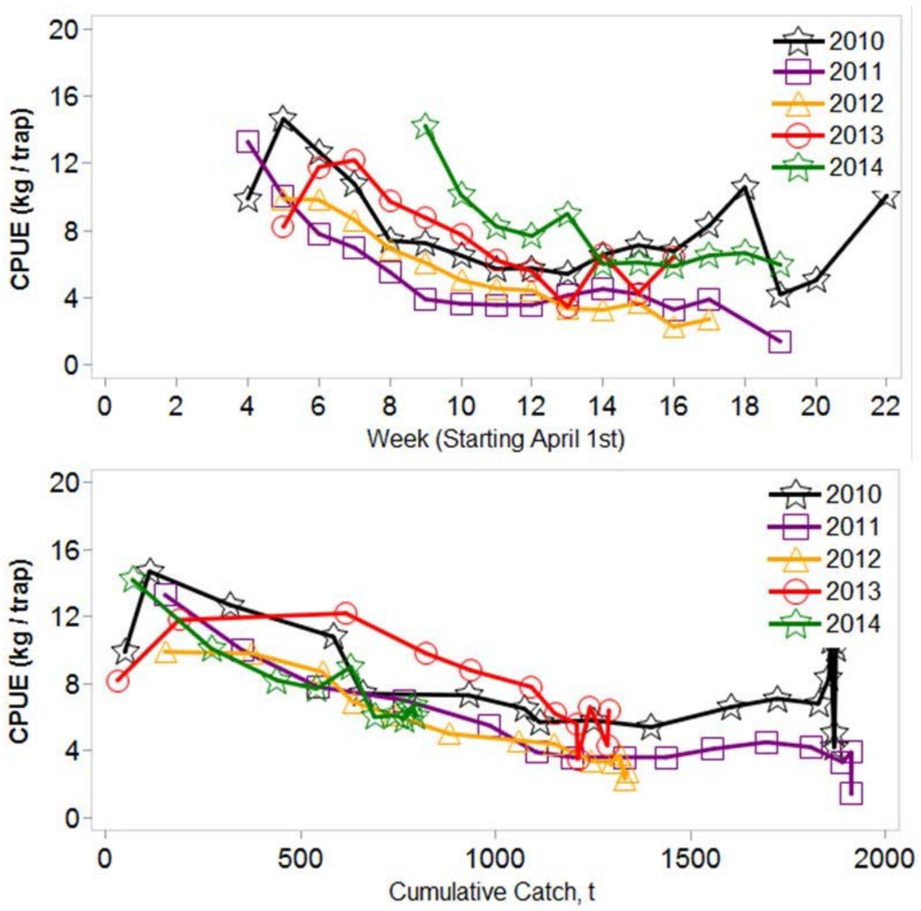


Figure 47: Seasonal trends in logbook CPUE for Divs. 2HJ; by week (above), and in relation to cumulative catch (below).

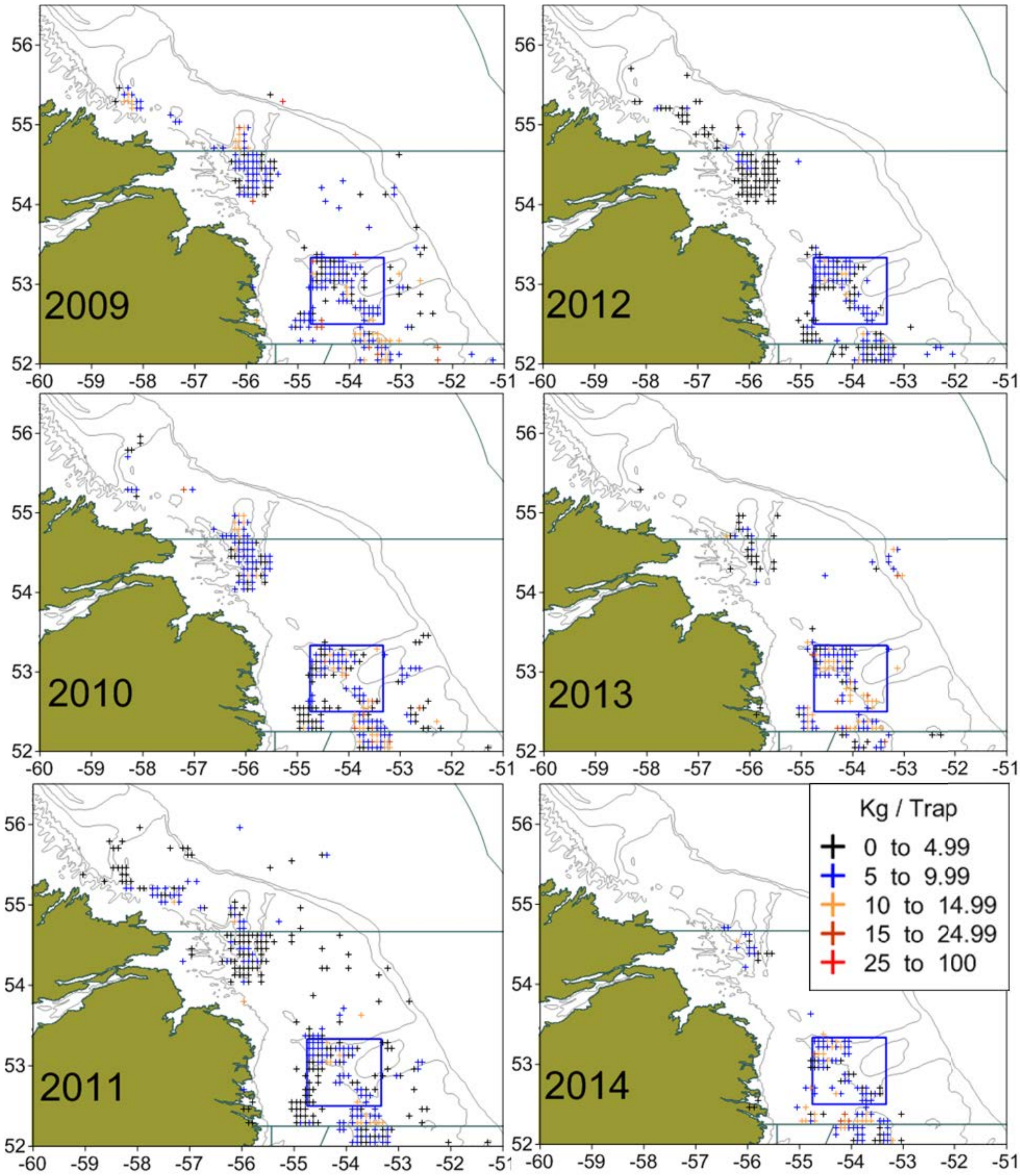


Figure 48: Spatial distribution of Divs. 2HJ logbook CPUE by year.

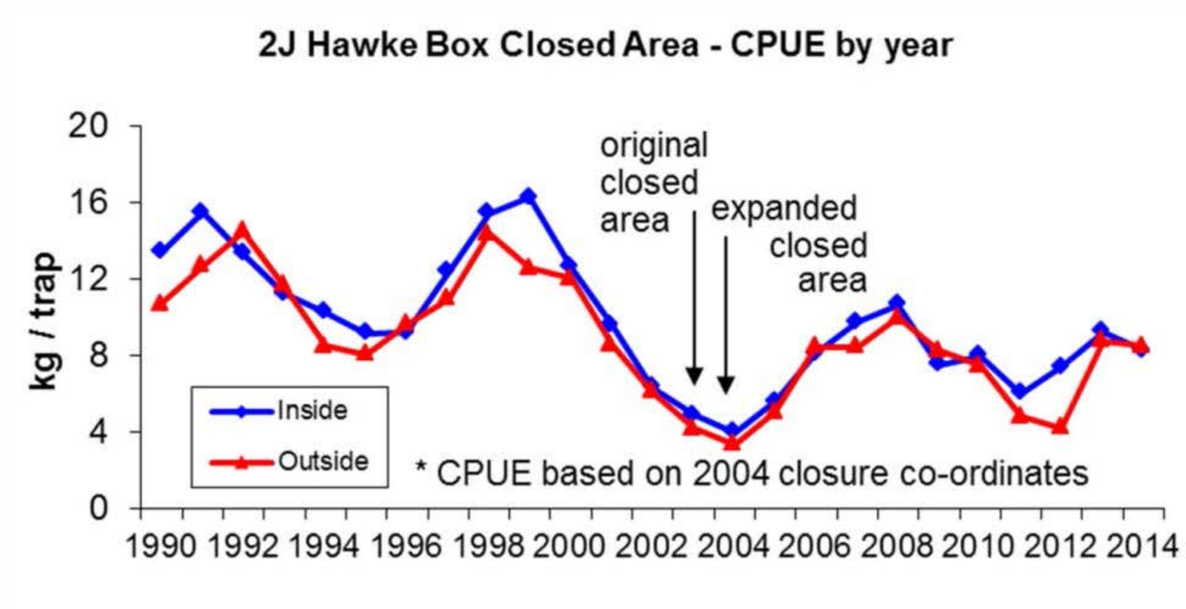


Figure 49: Trends in Div. 2J commercial logbook CPUE inside vs. outside the Hawke Channel closed area.

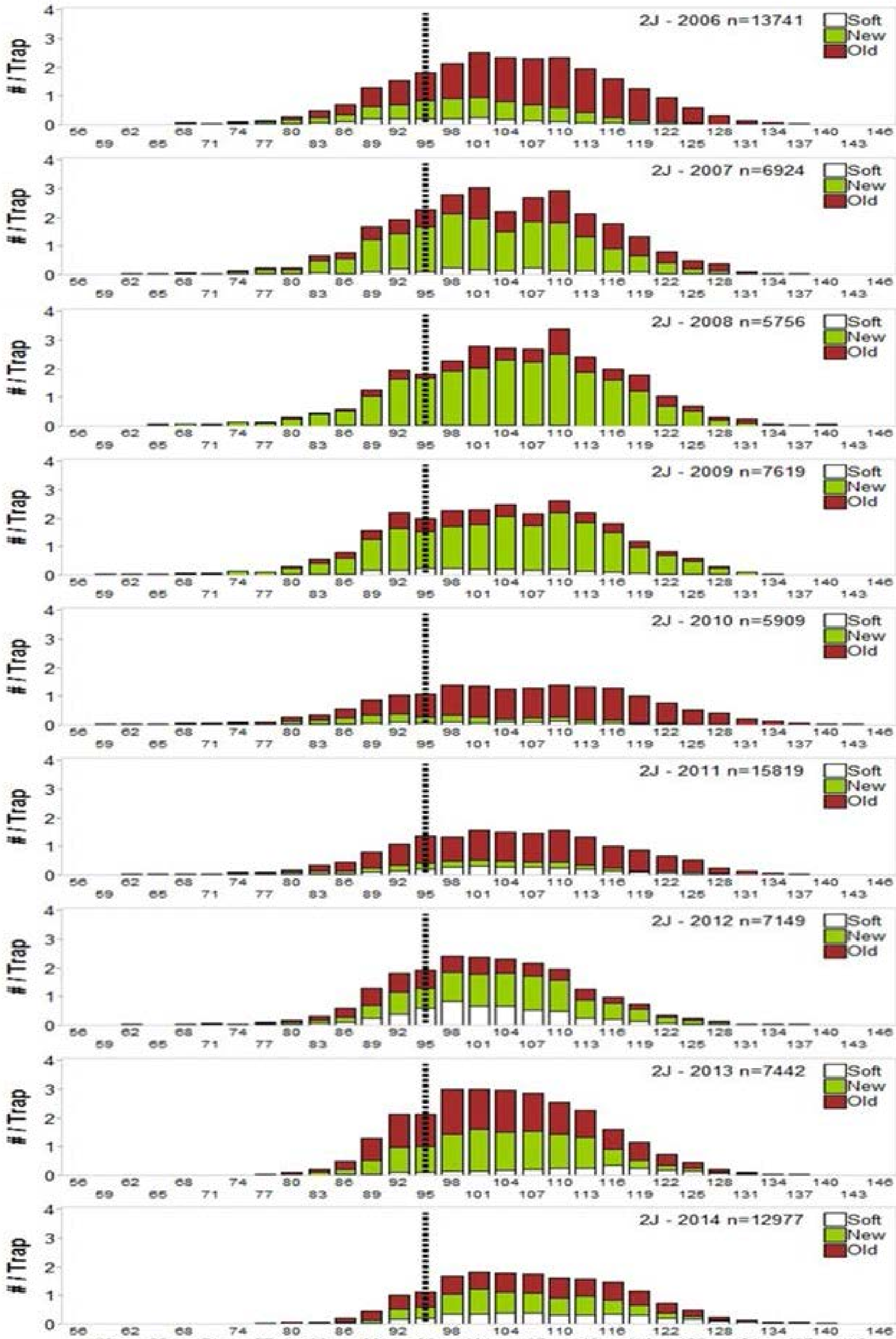


Figure 50: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Divs. 2HJ. The vertical dashed line indicates the minimum legal size.

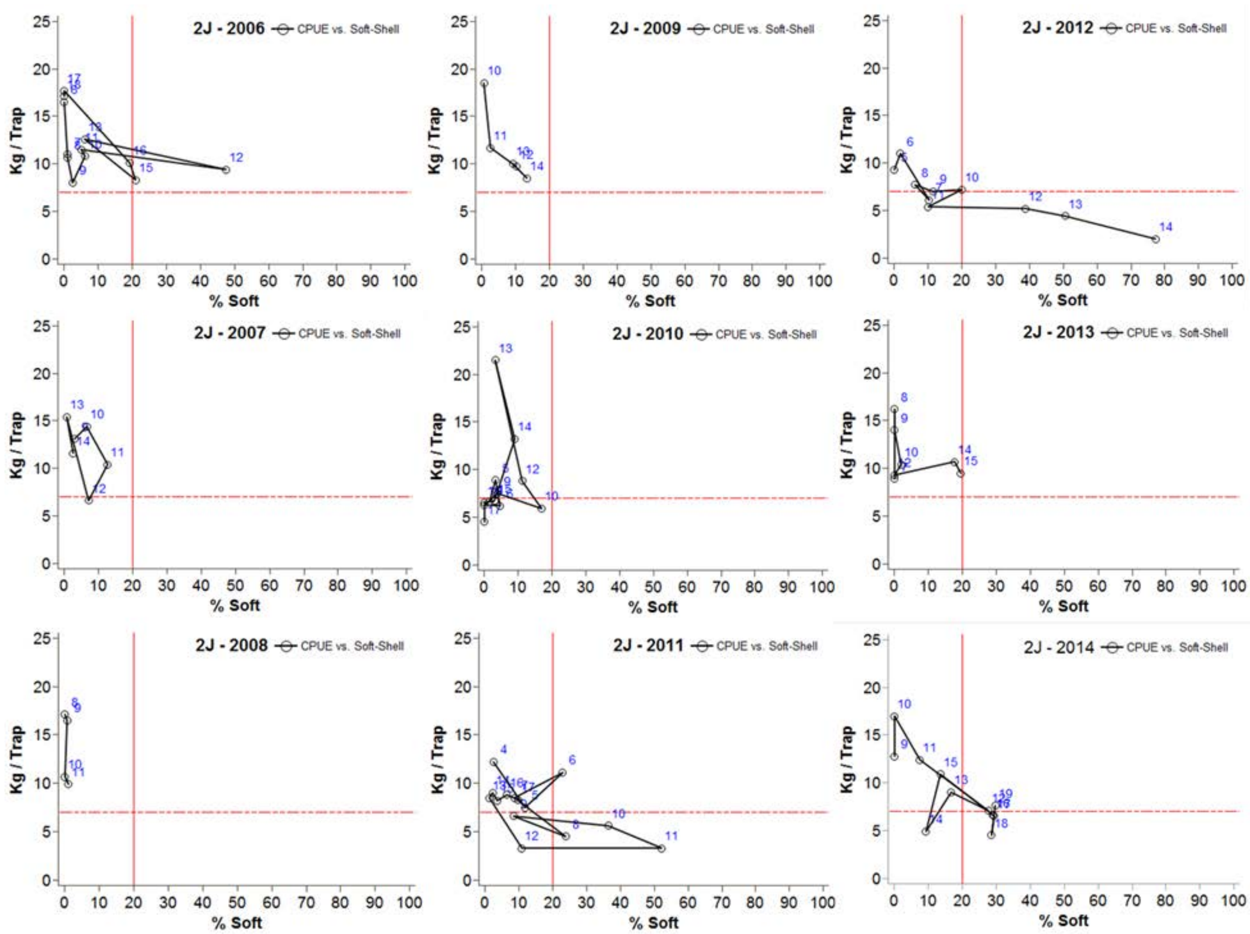


Figure 51: Trends in weekly percentages of kept vs. soft-shell crab in the Divs. 2HJ fishery from observer at-sea sampling by observers.

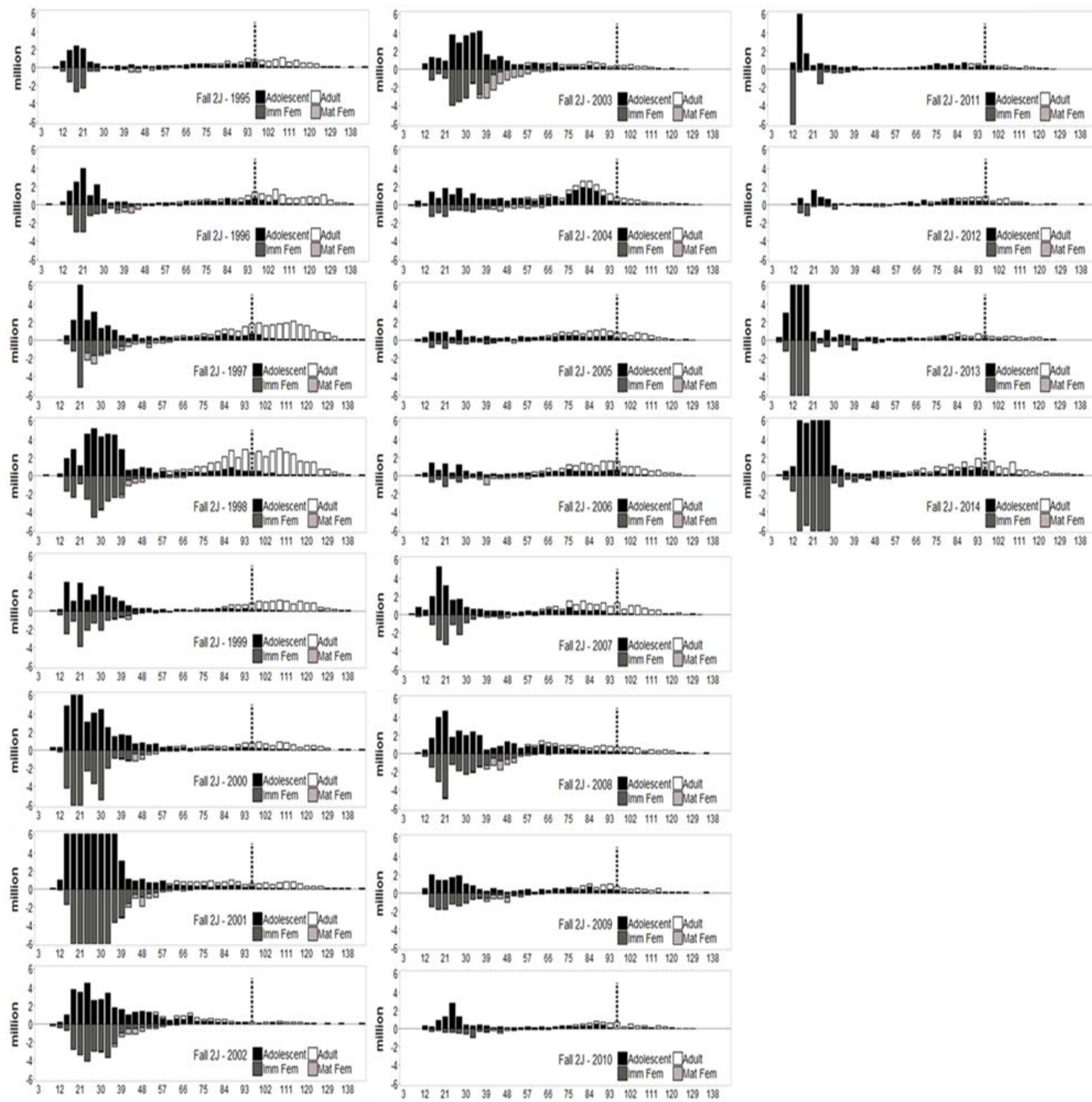


Figure 52. Abundance indices by carapace width for Divs. 2HJ juveniles plus adolescent males (dark bars), adult males (white bars), immature females (dark grey bars) and mature females (light grey bars) from fall trawl surveys.

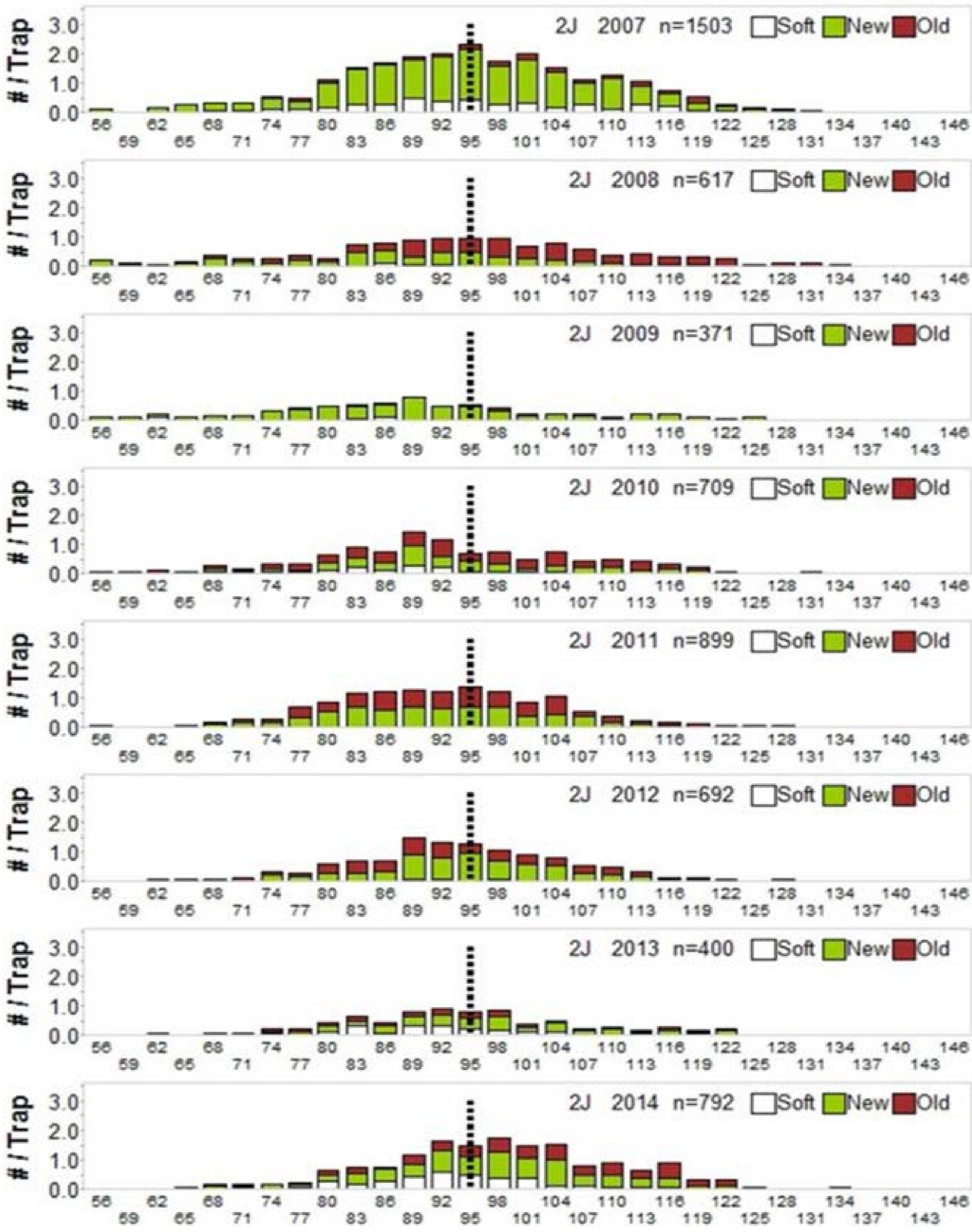


Figure 53: Trends in male carapace width distributions from large mesh traps at core stations in the Div. 2J offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

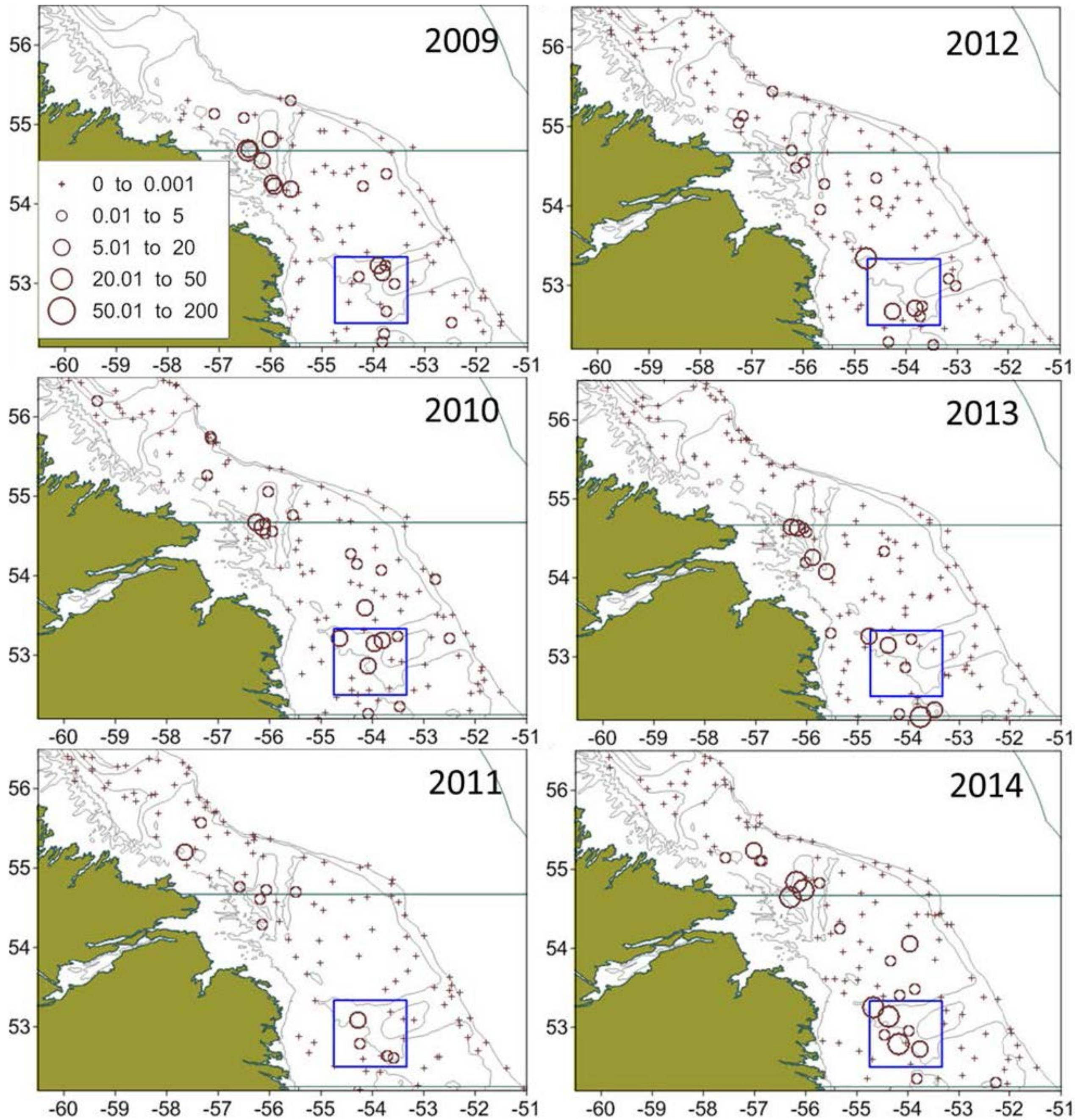


Figure 54: Distribution (#/tow) of exploitable males (> 94 mm CW adults) from Divs. 2HJ fall bottom trawl surveys from 2009--14.

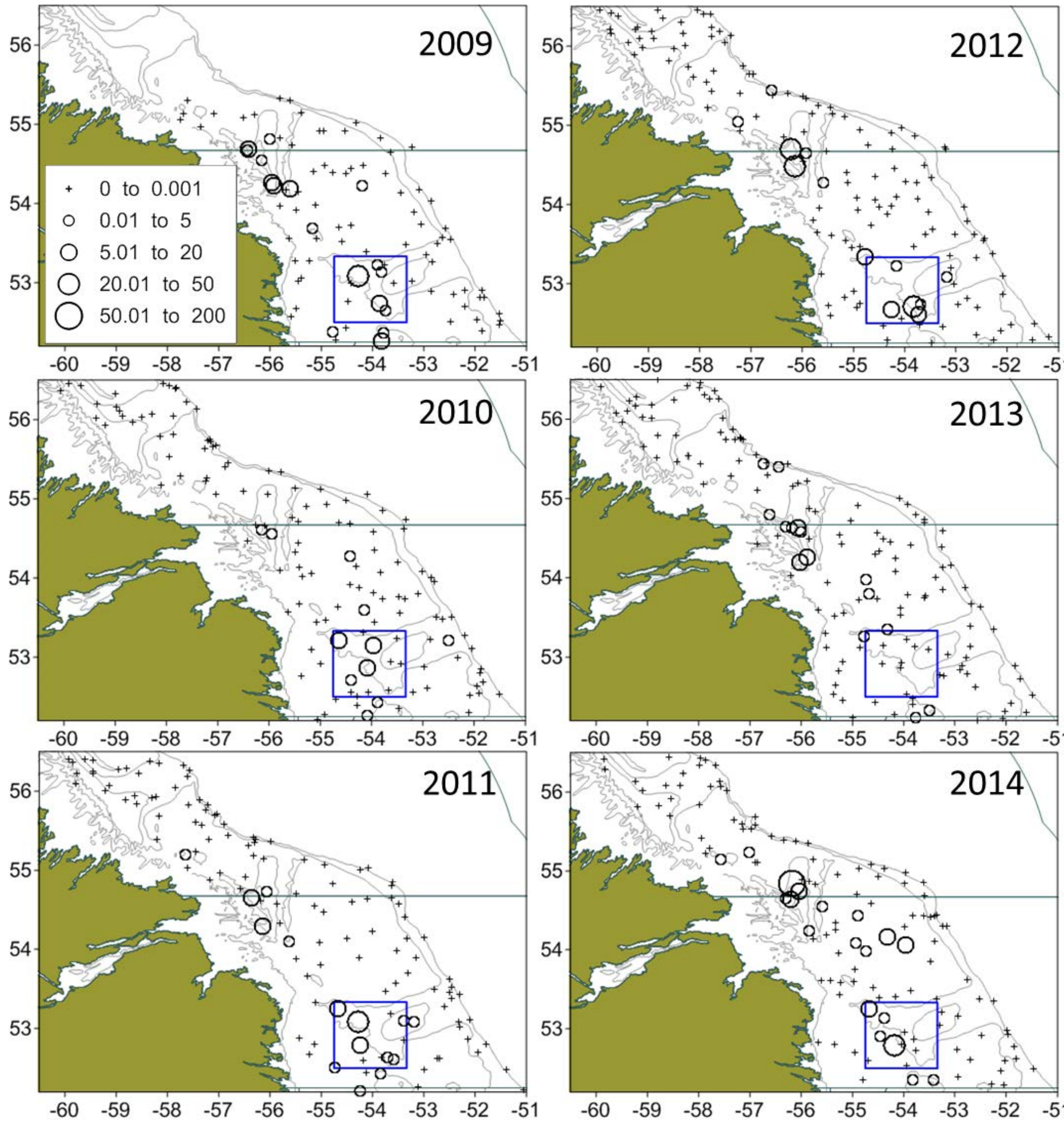


Figure 55: Distribution (#/tow) of pre-recruit males (> 75 mm CW adolescent) from Divs. 2HJ fall bottom trawl surveys from 2009-14.

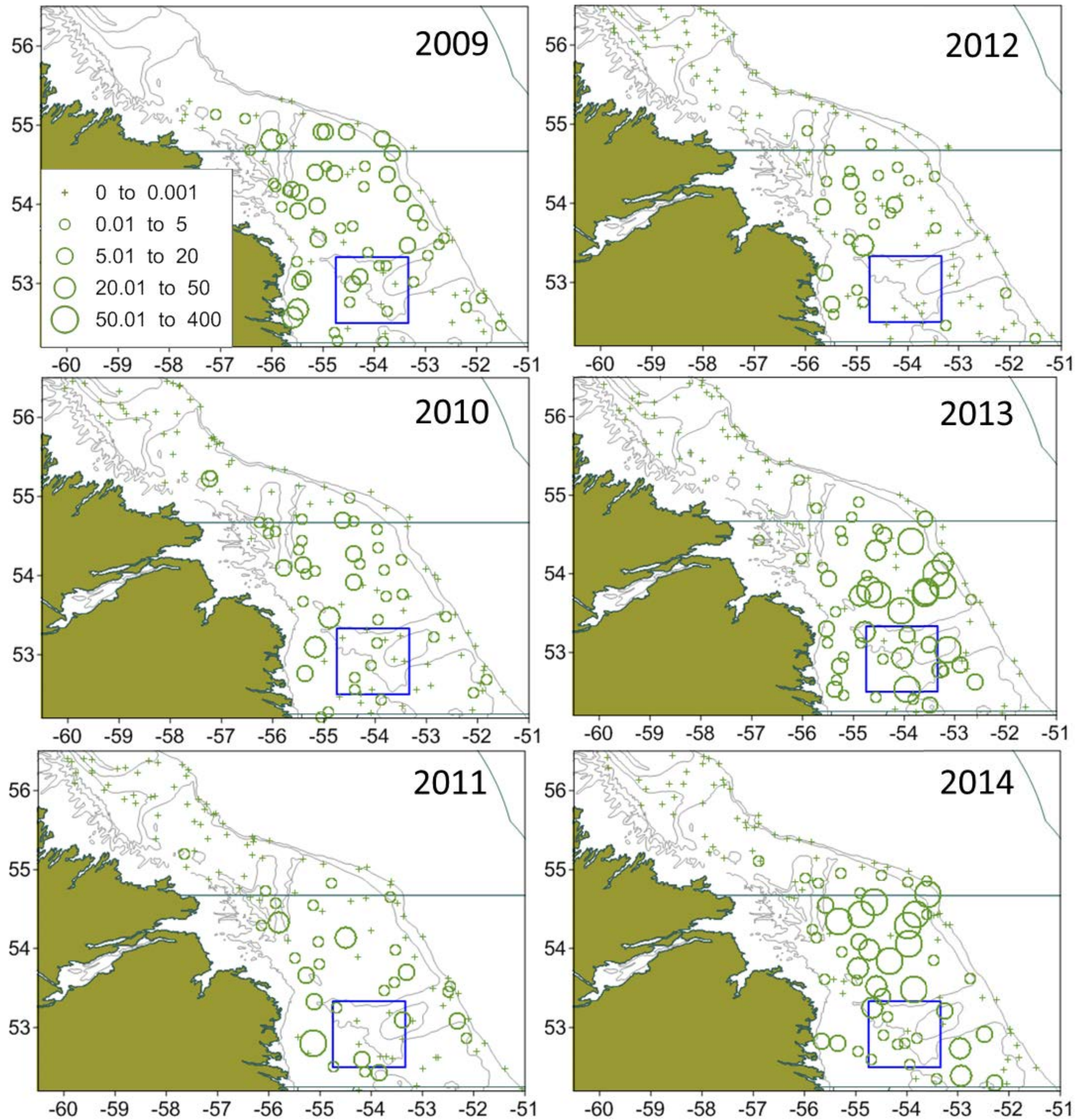


Figure 56: Distribution (#/tow) of small males (< 60 mm CW adolescents) in the Divs. 2HJ fall bottom trawl surveys from 2009-14.

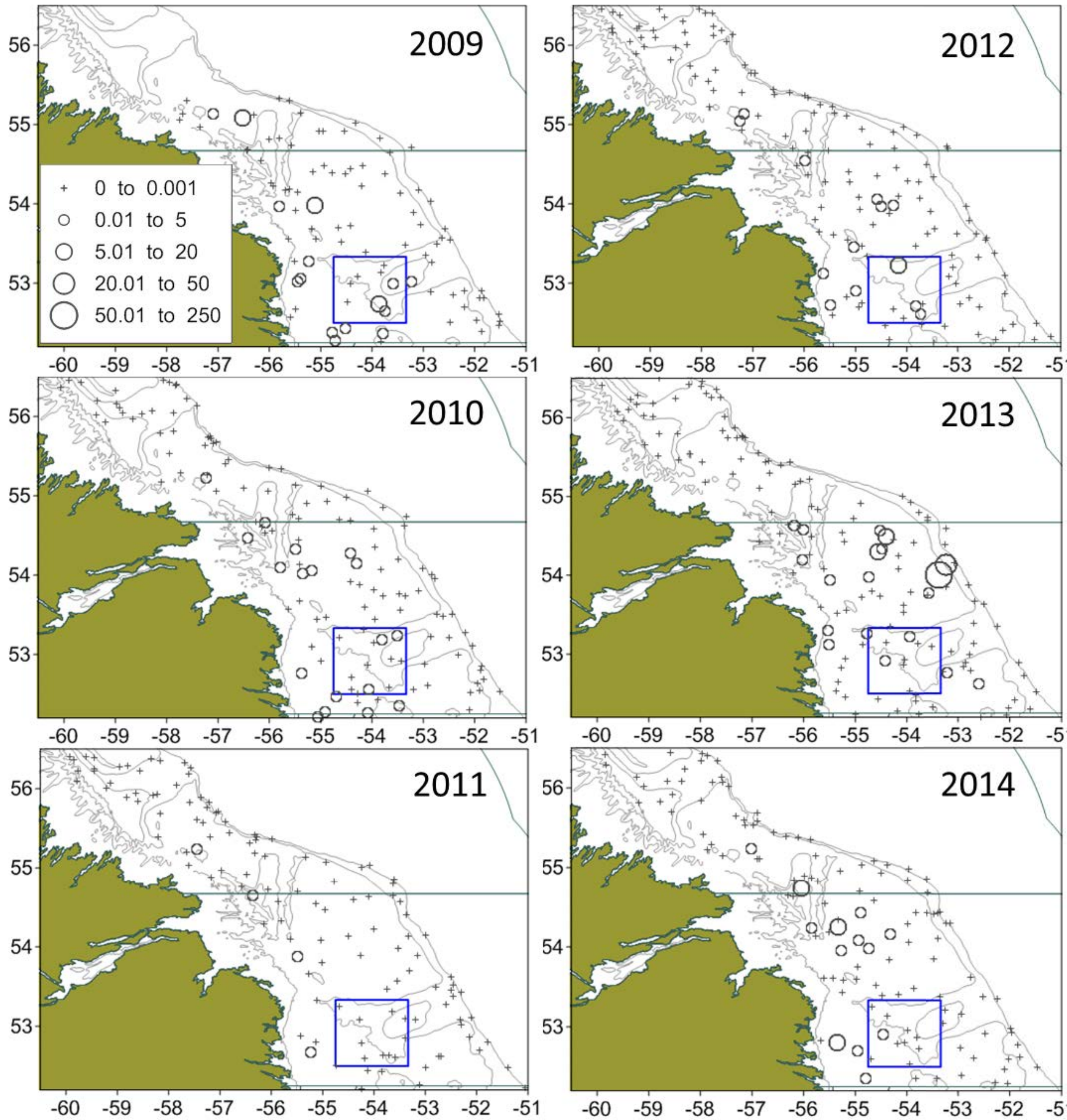


Figure 57: Distribution (#/tow) of mature females in the Divs. 2HJ fall bottom trawl surveys from 2009-14.

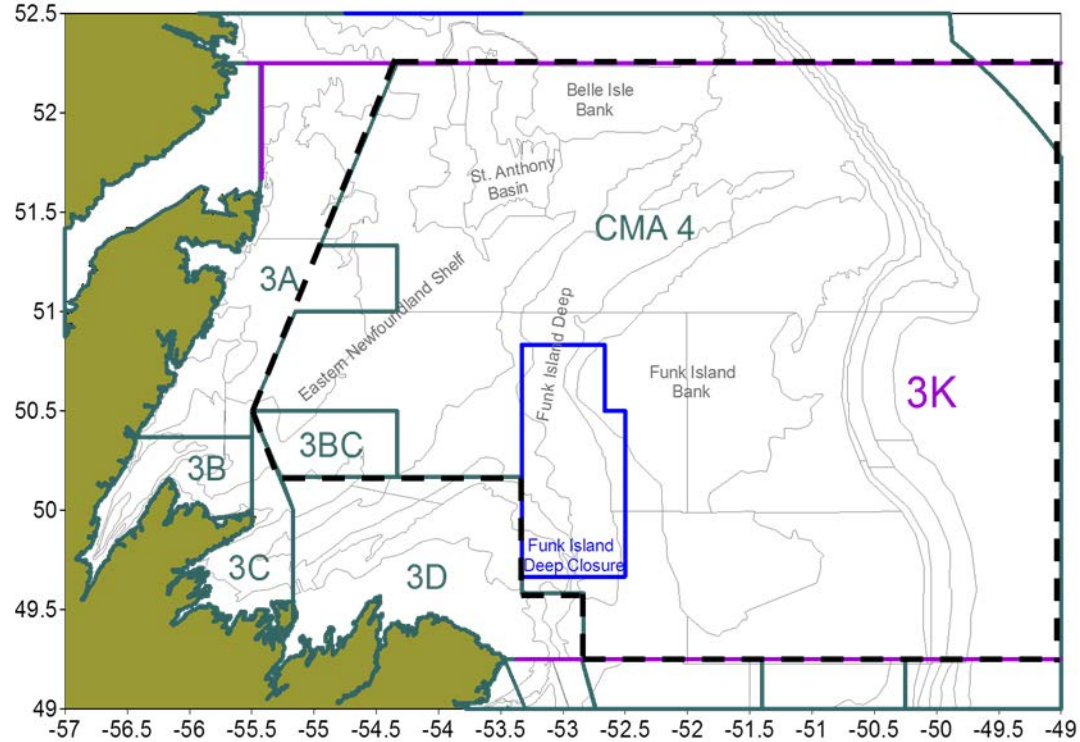


Figure 58: Map of Div. 3K showing CMAs and important bathymetric features as well as the Funk Island Deep closed area. Dashed perimeter indicates the offshore area.

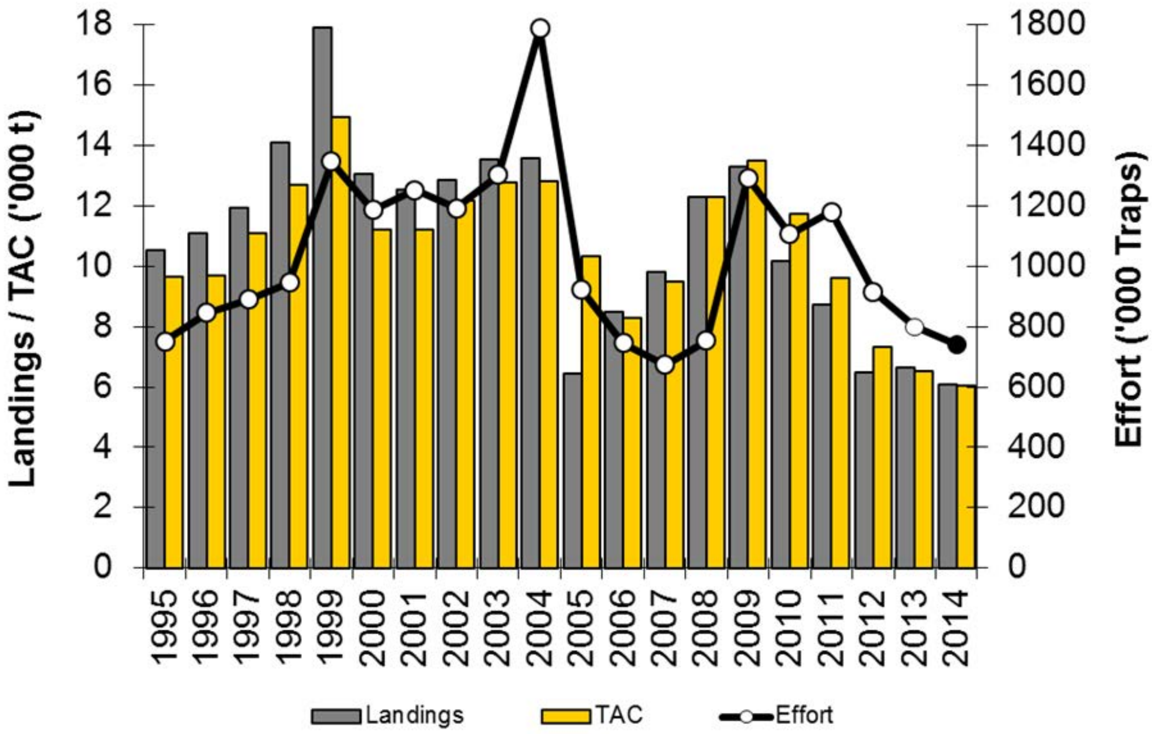


Figure 59: Trends in Div. 3K offshore landings, TAC, and fishing effort. 2014 effort preliminary.

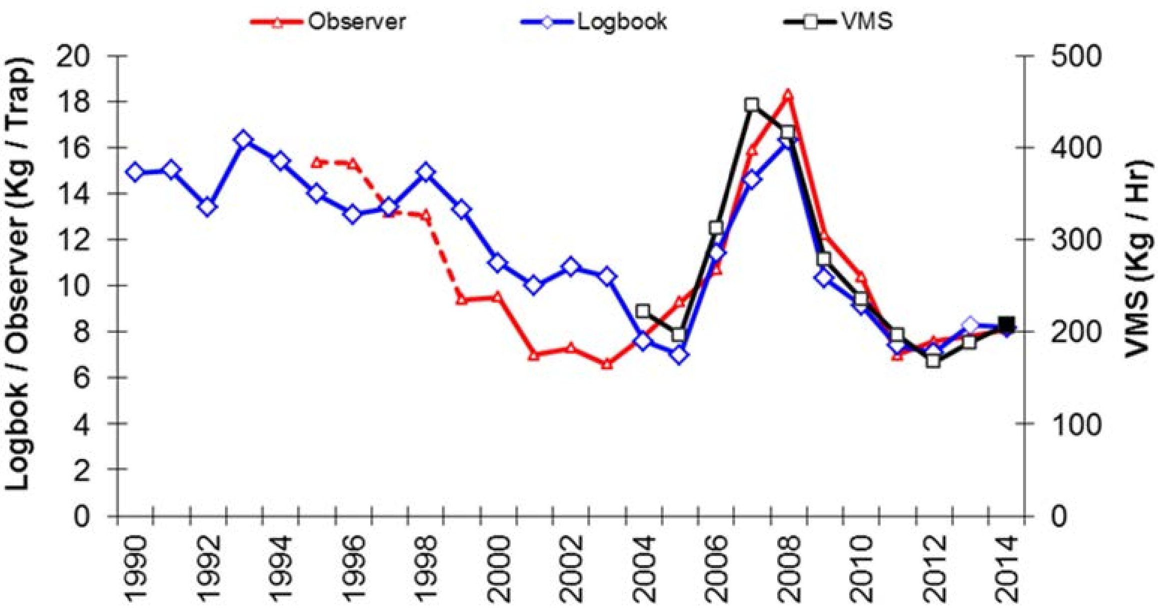


Figure 60: Trends in commercial logbook-based, observer-based, and VMS-based CPUE in the Div. 3K offshore fishery. 2014 logbook and VMS CPUE estimates preliminary.

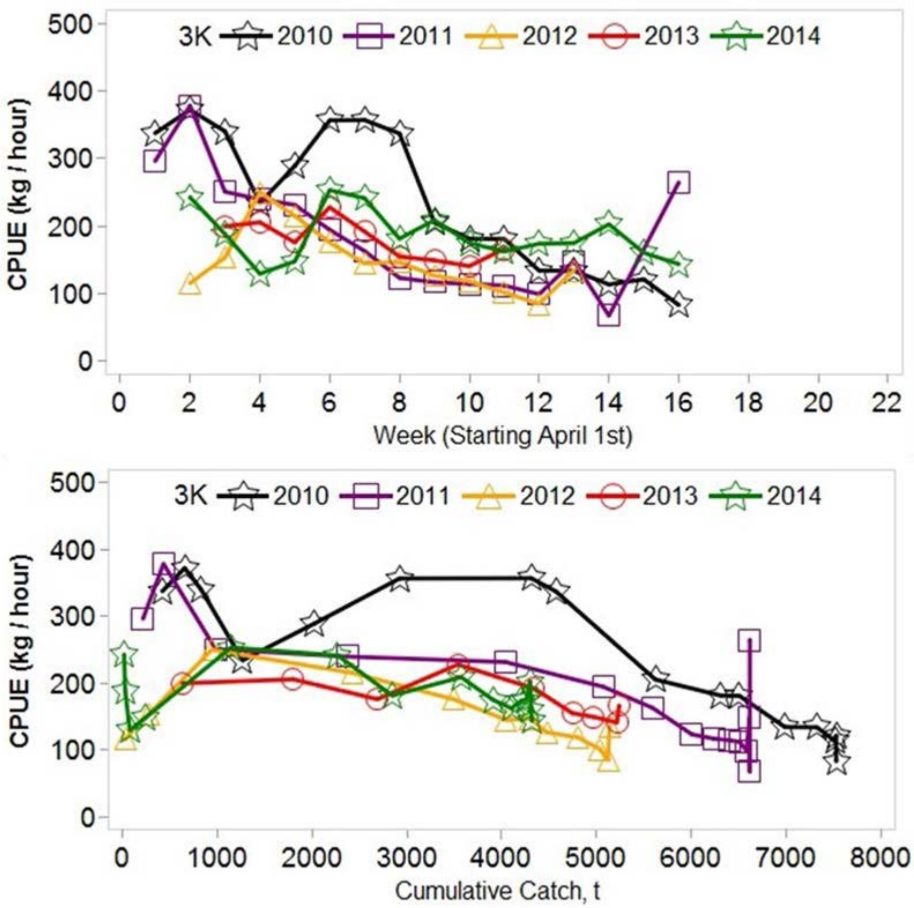


Figure 61: Seasonal trends in VMS-based CPUE for Div. 3K offshore; by week, (above) and in relation to cumulative catch (below).

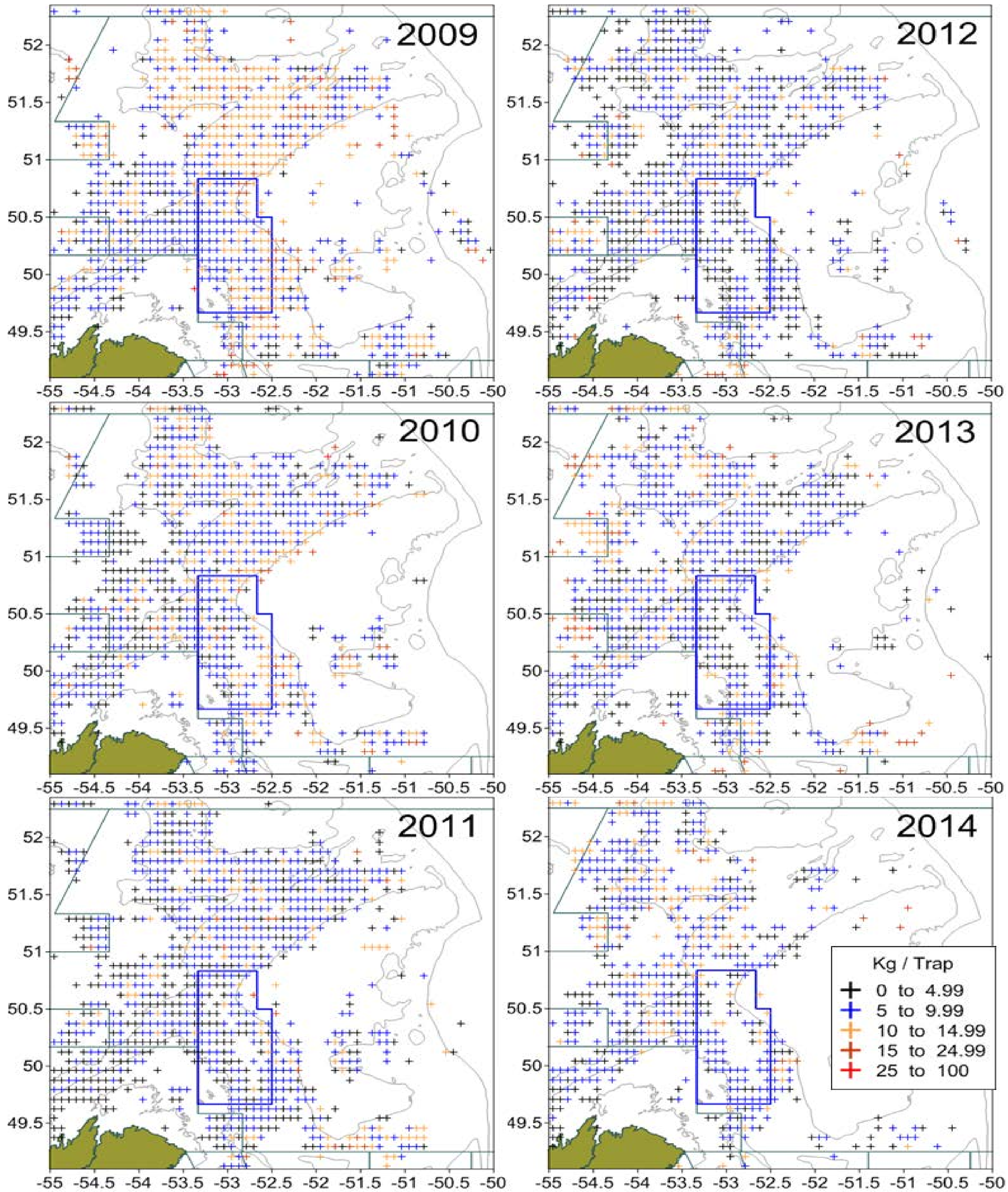


Figure 62: Spatial distribution of Div. 3K logbook CPUE by year.

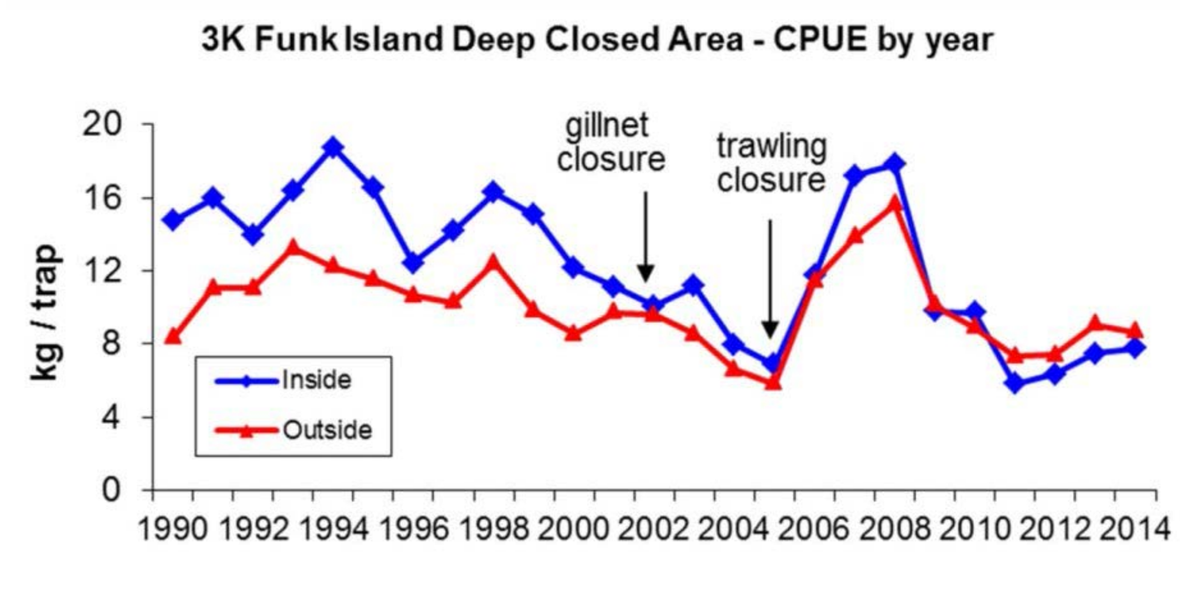


Figure 63: Div. 3K offshore commercial CPUE inside vs. outside the Funk Island Deep closed area.

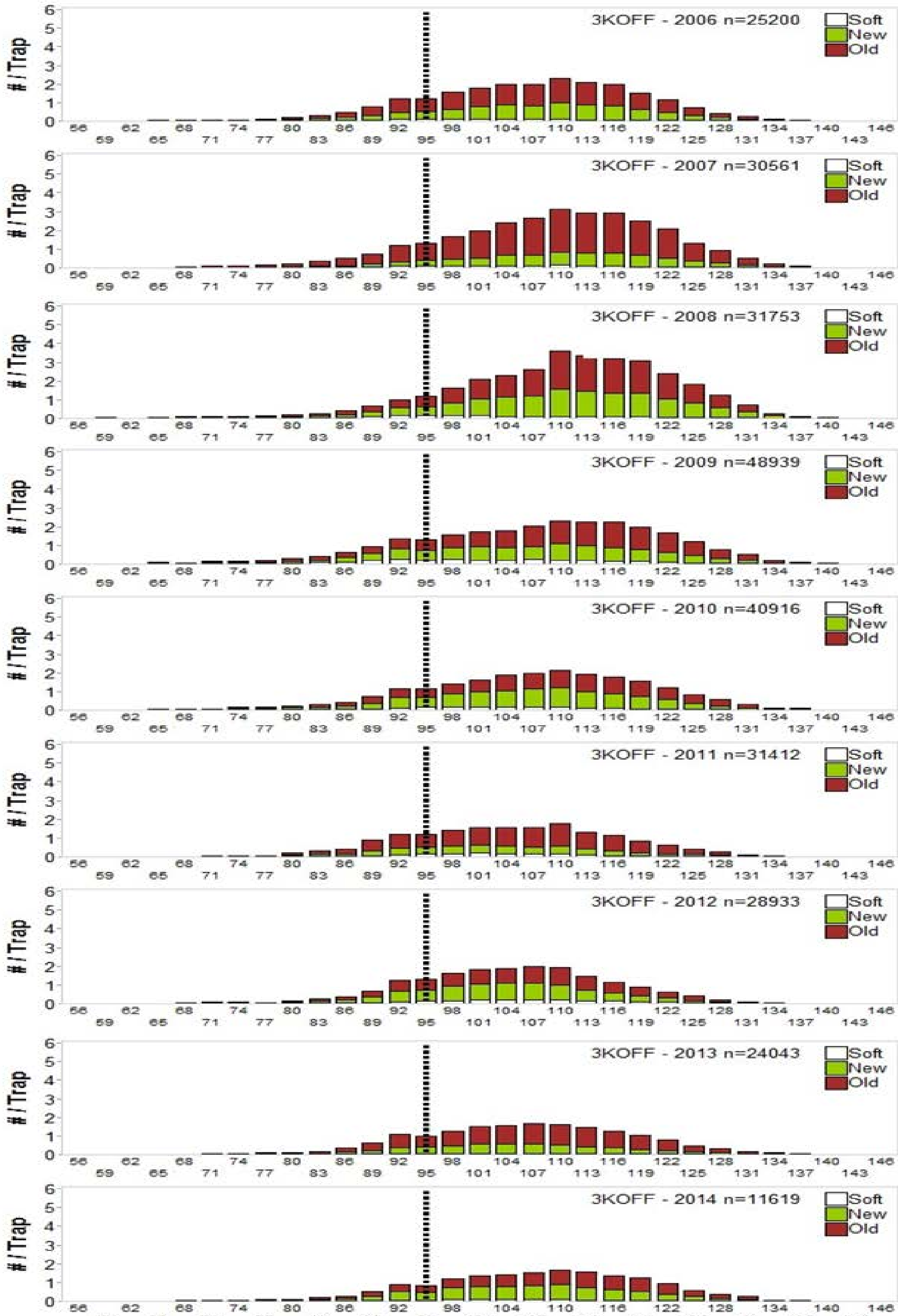


Figure 64: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Div. 3K offshore. The vertical dashed line indicates the minimum legal size.

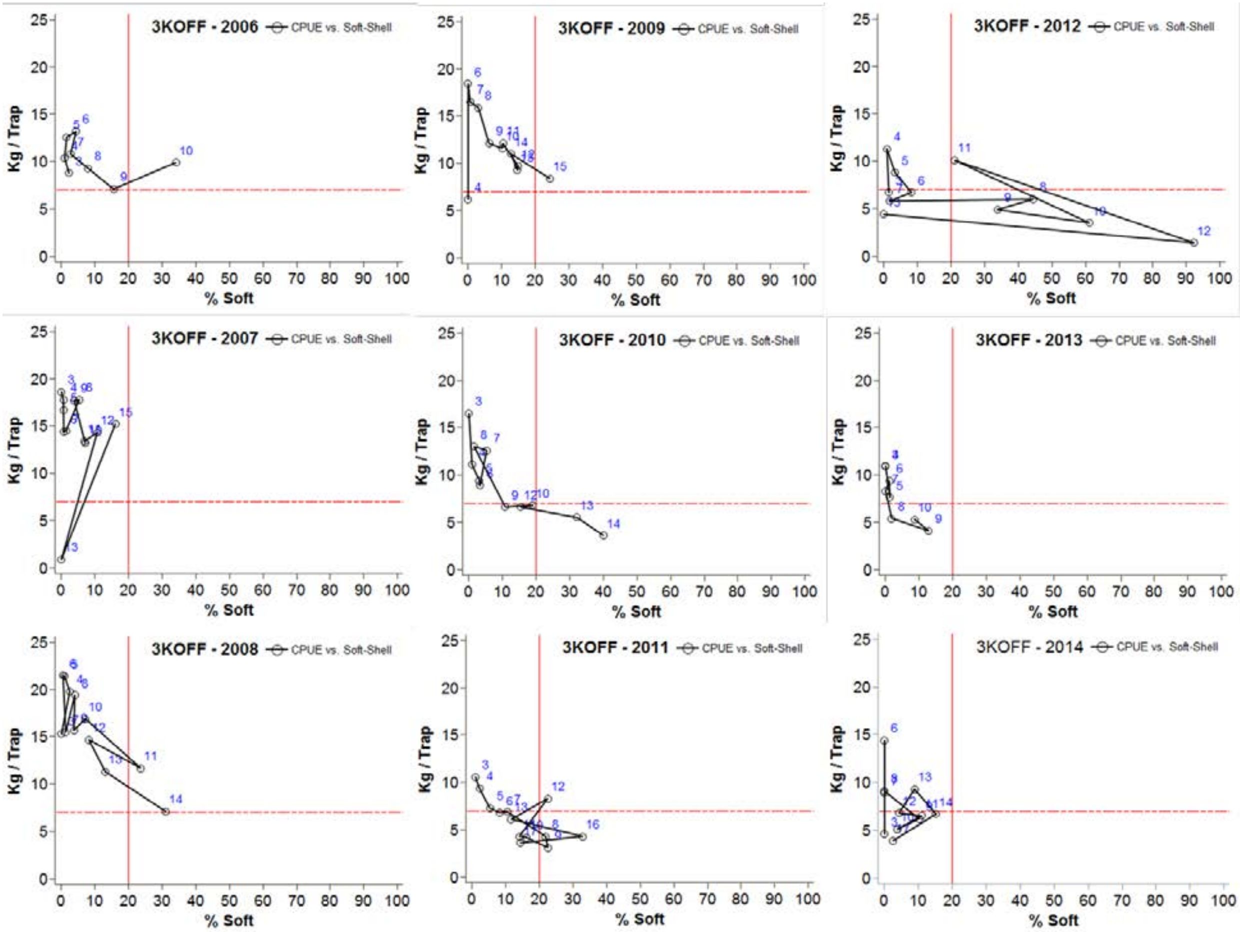


Figure 65: Trends in weekly percentages of kept vs. soft-shell crab in the Div. 3K offshore fishery from at-sea sampling by observers.

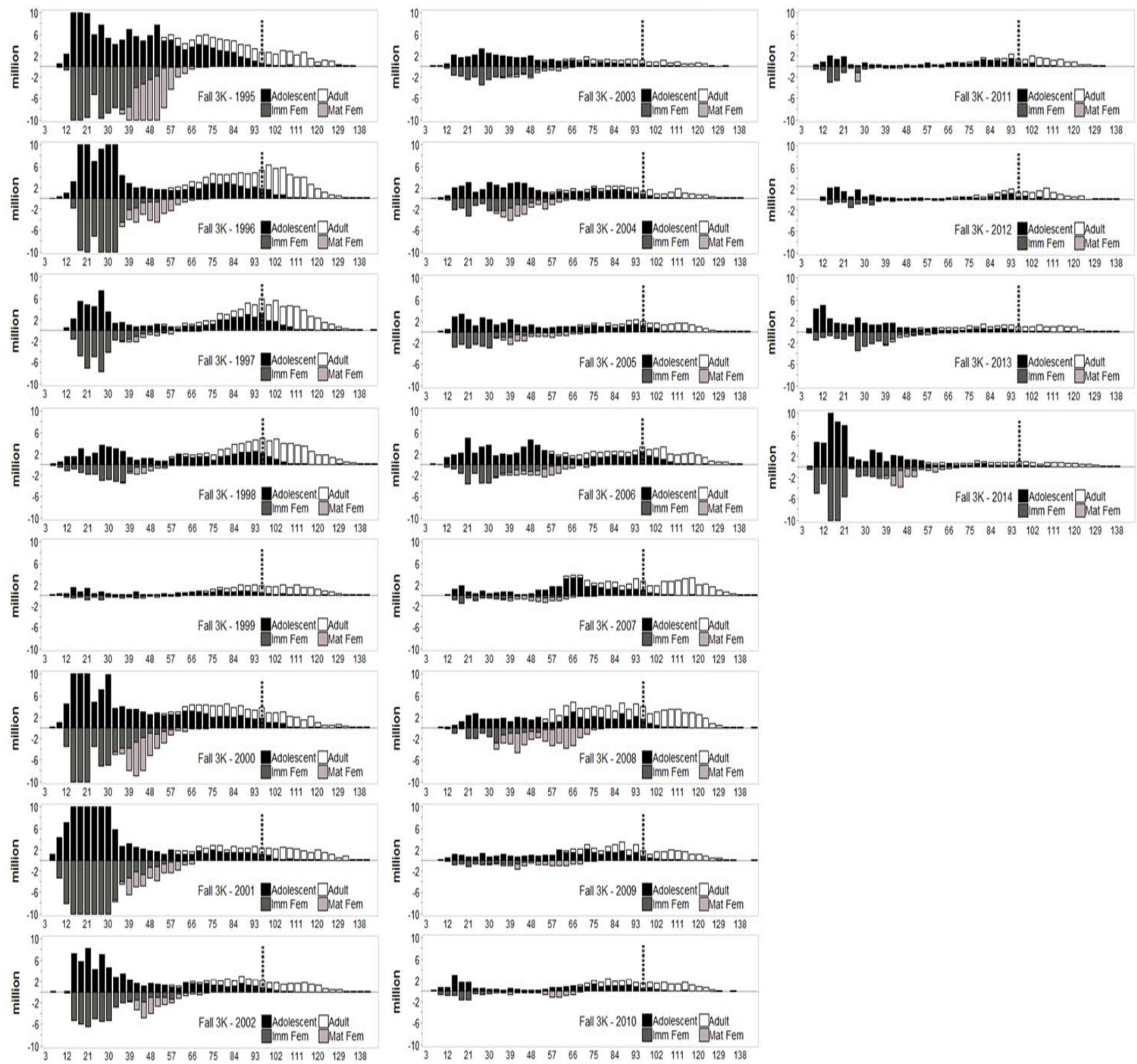


Figure 66: Abundance indices by carapace width for Div. 3K offshore juveniles plus adolescent males (dark bars), adult males (white bars), immature females (dark grey bars) and mature females (light grey bars) from fall trawl surveys.

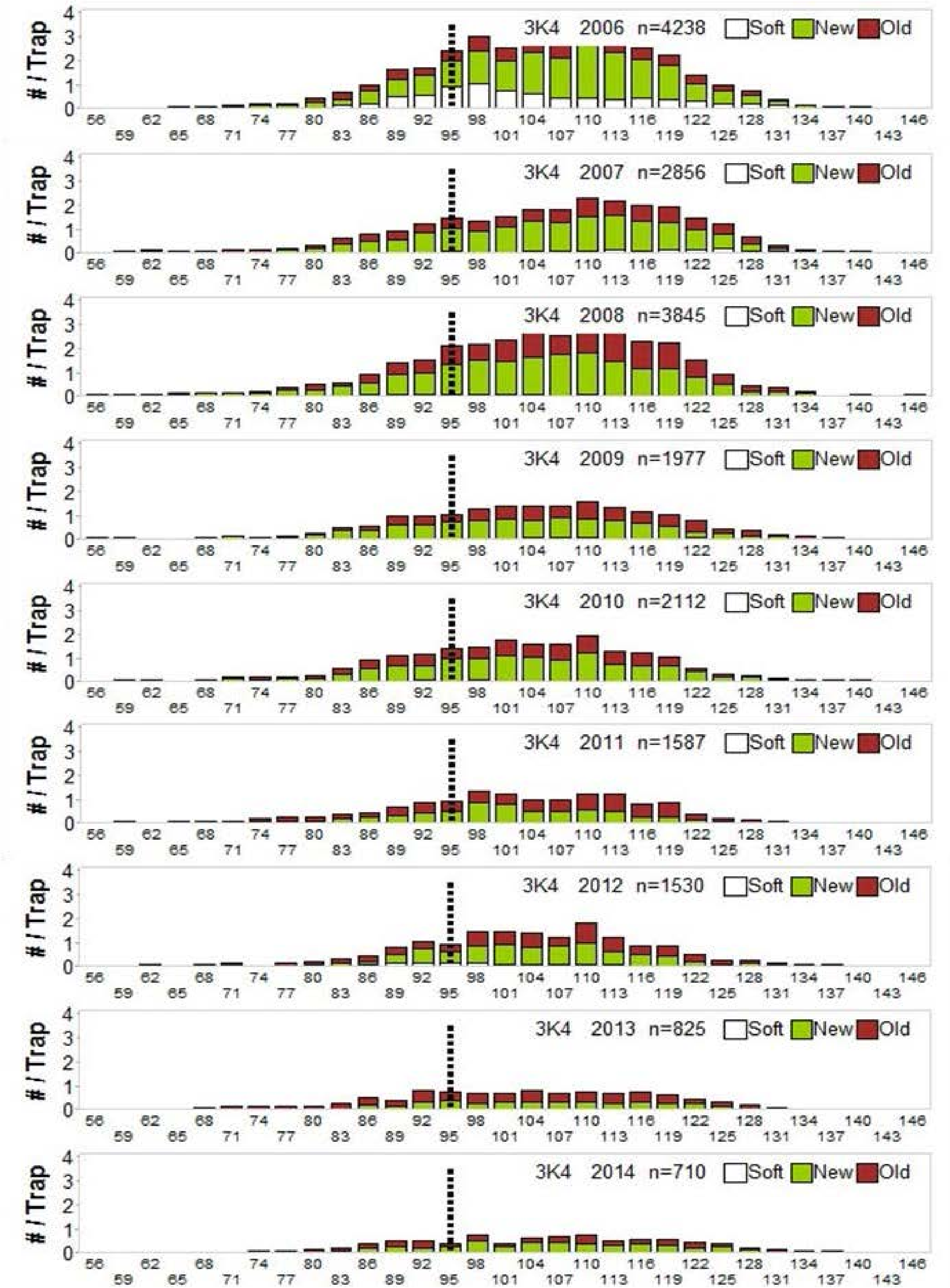


Figure 67: Trends in male carapace width distributions from large mesh traps at core stations in the Div. 3K offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

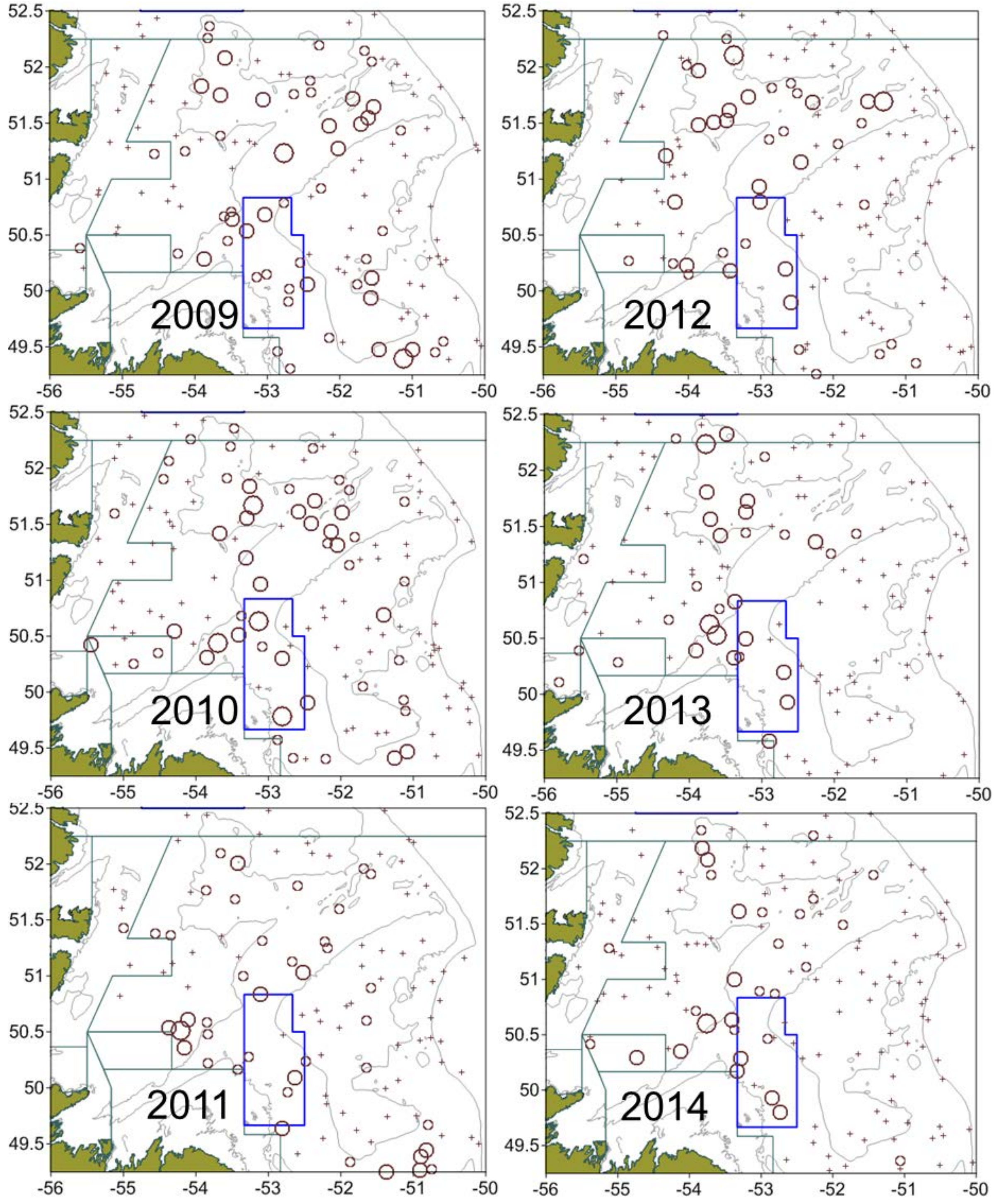


Figure 68. Distribution (#/tow) of exploitable males (> 94 mm CW adults) from Div. 3K fall bottom trawl surveys from 2009-14.

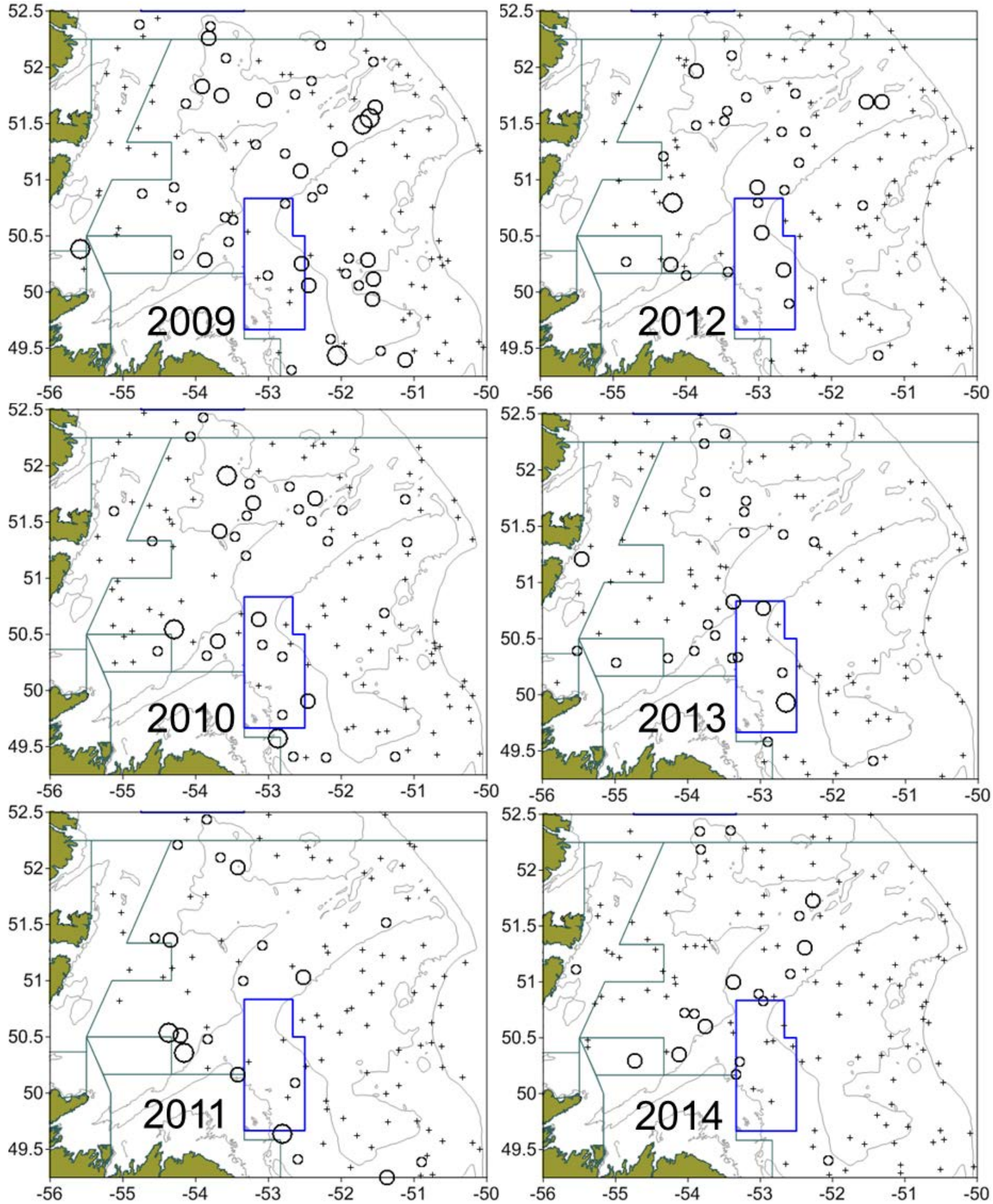


Figure 69. Distribution (#/tow) of pre-recruit males (> 76 mm CW adolescents) from Div. 3K fall bottom trawl surveys from 2009-14.

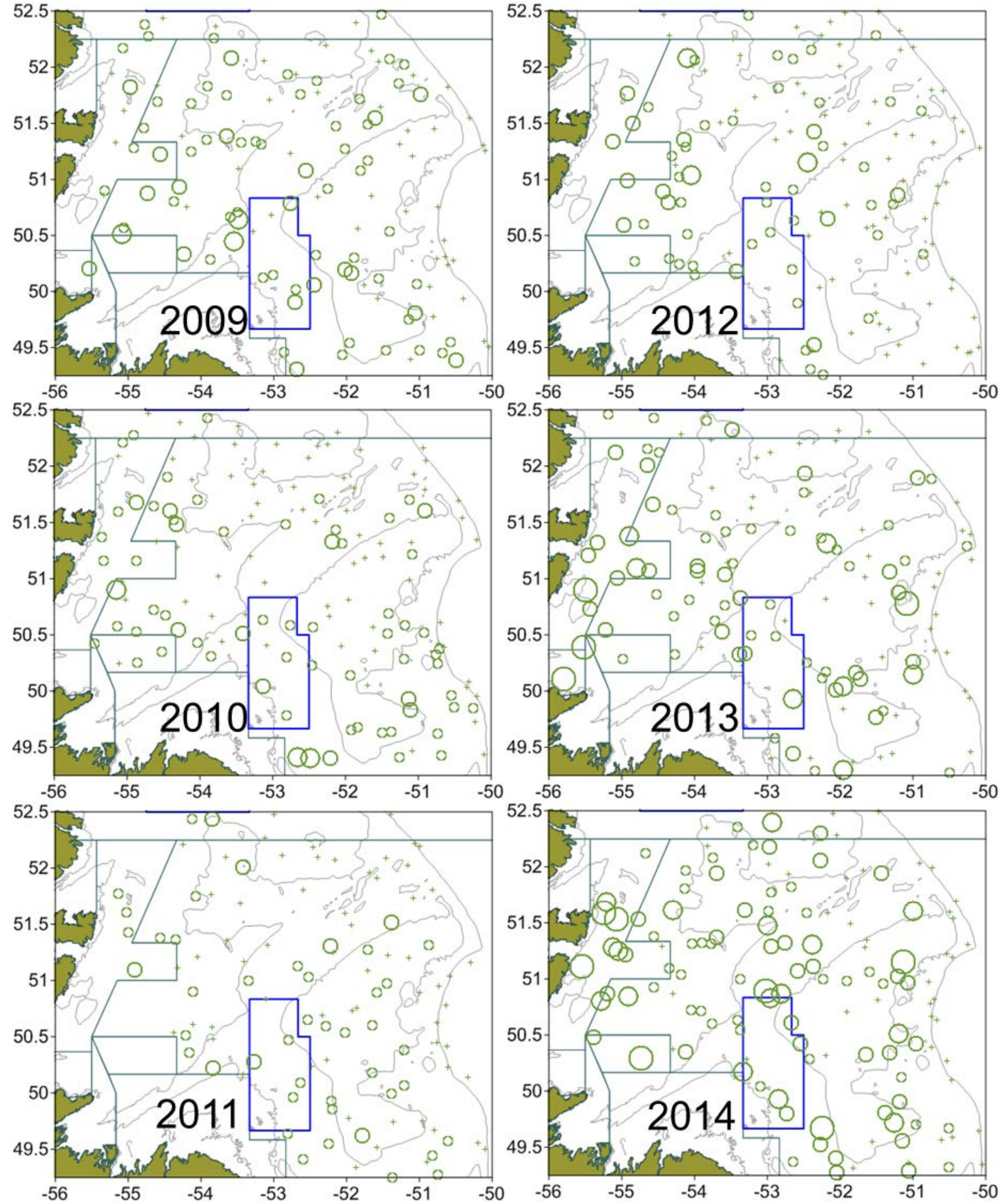


Figure 70. Distribution (#/tow) of small males (< 60 mm CW adolescents) from Div. 3K fall bottom trawl surveys from 2009-14.

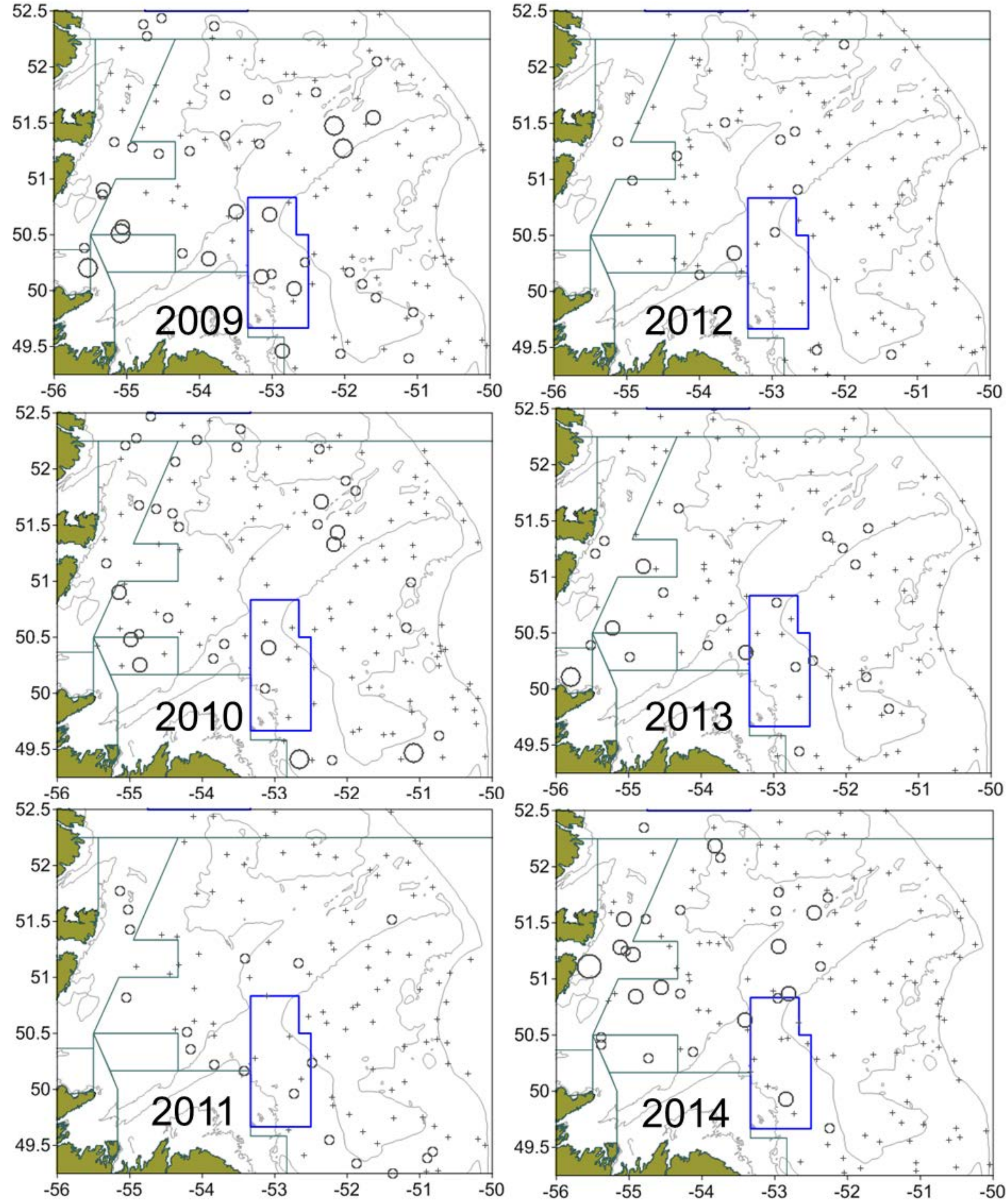


Figure 71. Distribution (#/tow) of mature females from Div. 3K fall bottom trawl surveys from 2009-14.

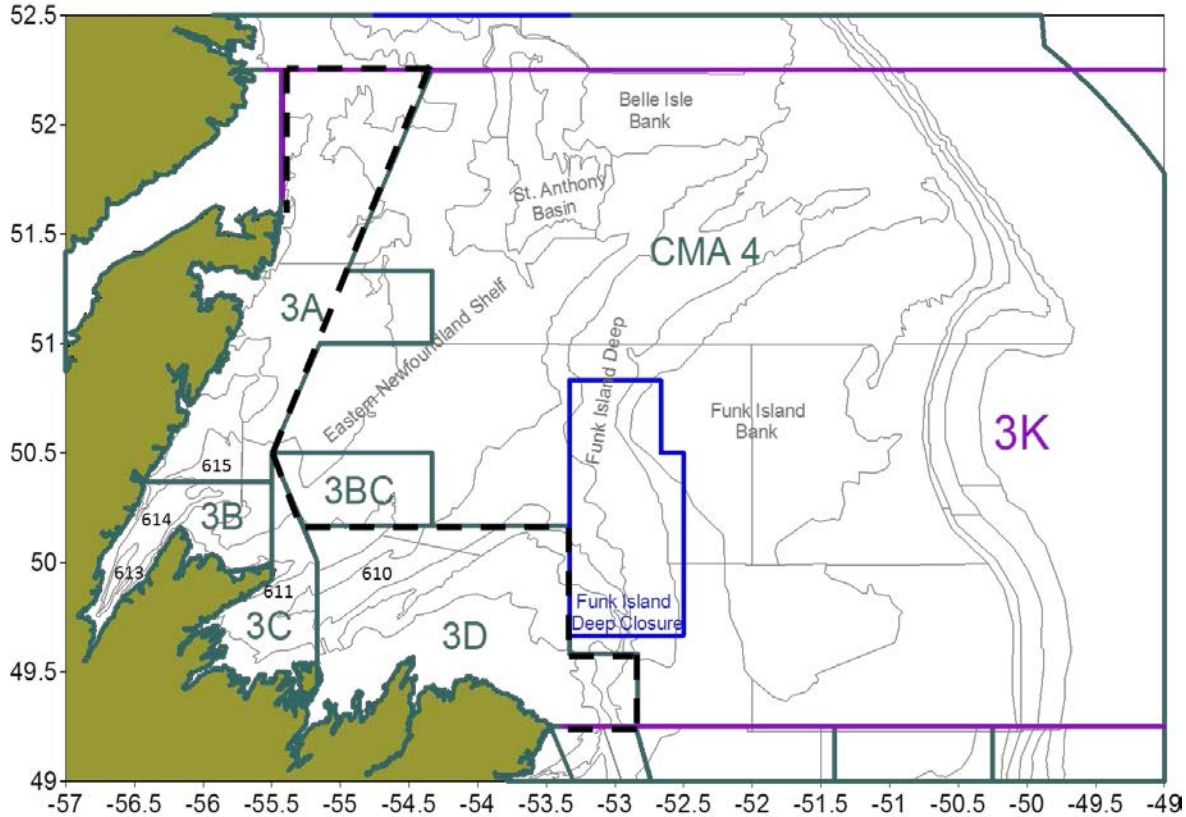


Figure 72: Map of Div. 3K showing CMAs and important bathymetric features as well as the Funk Island Deep closed area (blue box). Dashed perimeter indicates inshore areas.

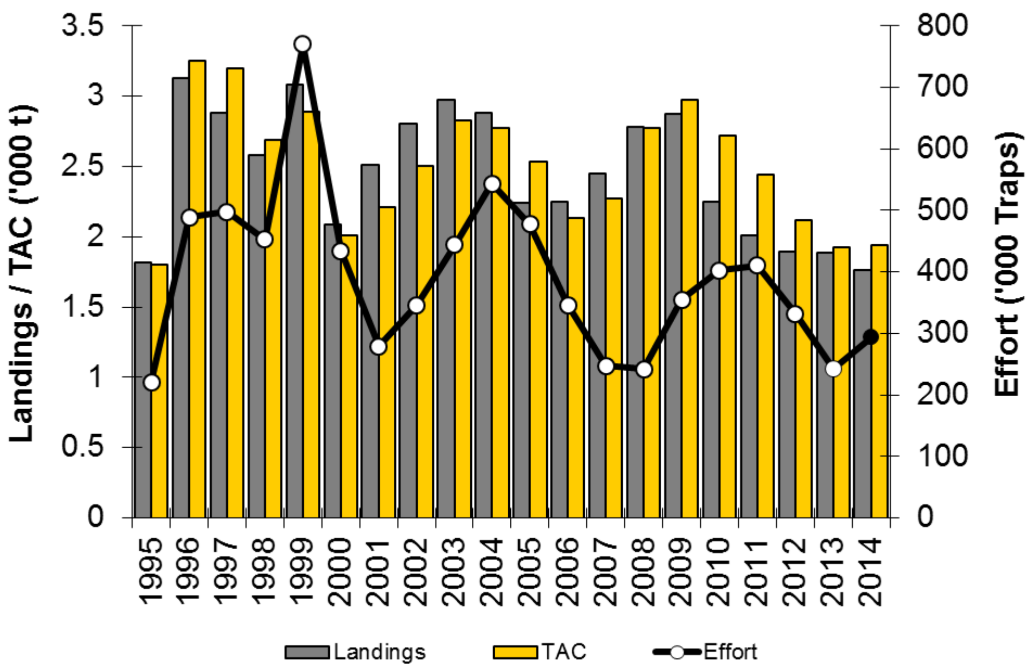


Figure 73: Trends in Div. 3K inshore landings, TAC, and fishing effort. 2014 effort preliminary.

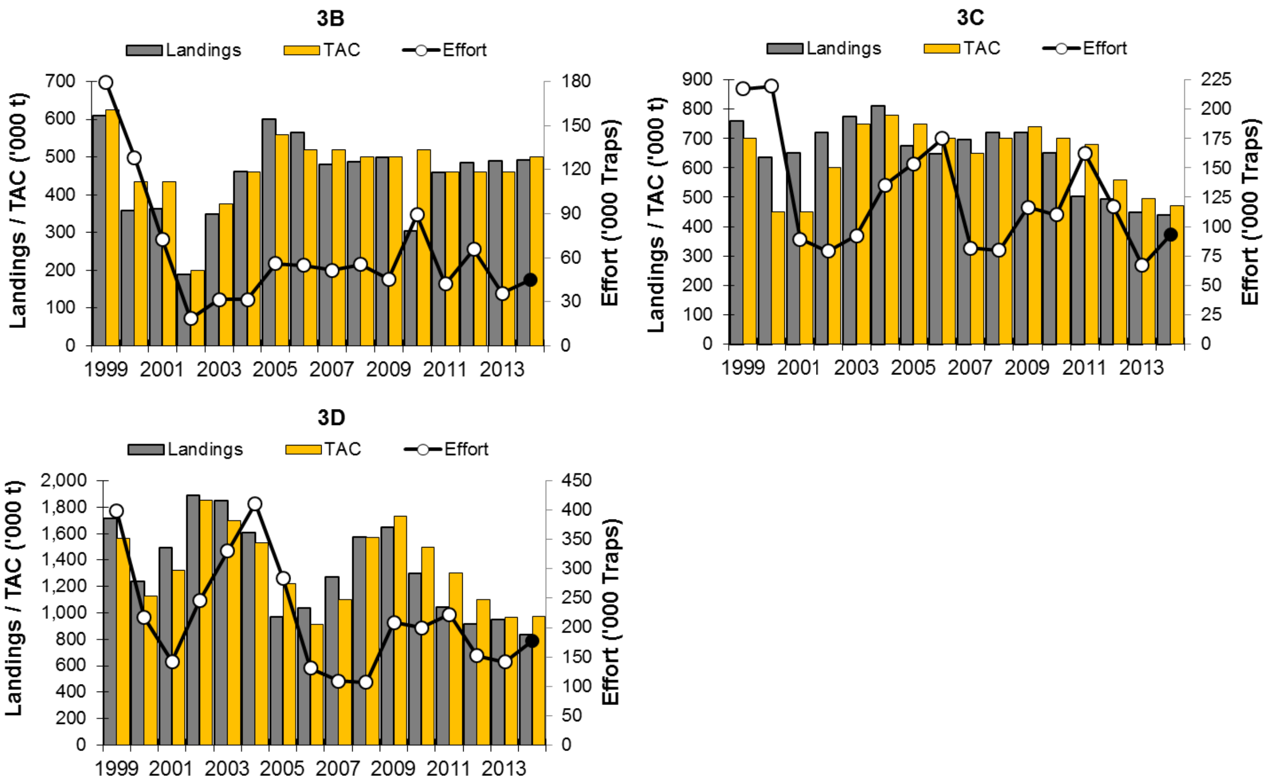


Figure 74: Trends in Div. 3K inshore areas landings, TAC, and fishing effort by CMAs. 2014 effort preliminary.

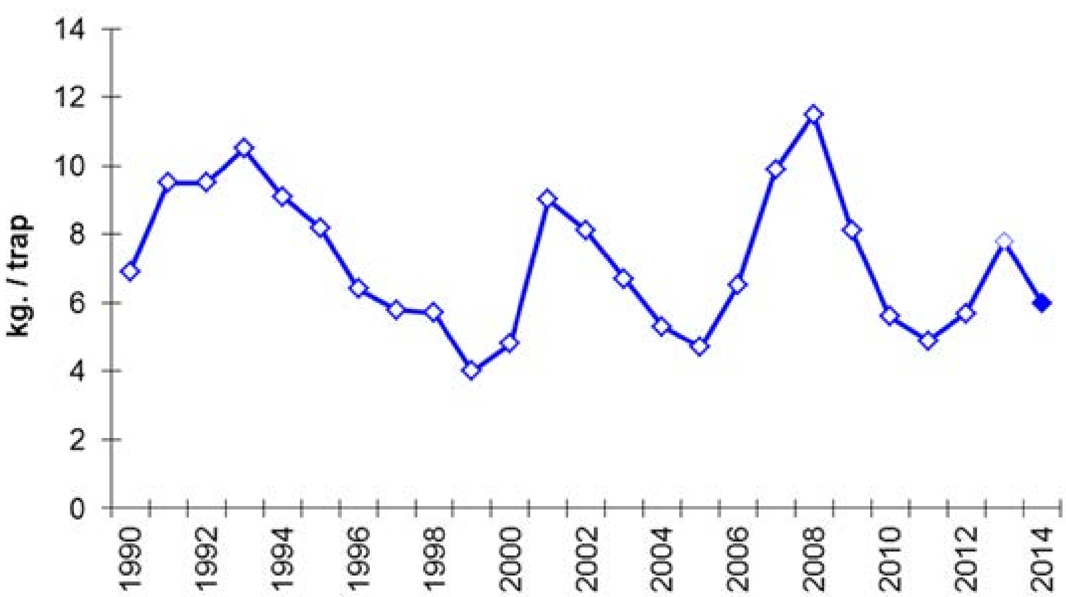


Figure 75: Trends in commercial logbook-based CPUE in the Div. 3K inshore fishery. 2014 estimate preliminary.

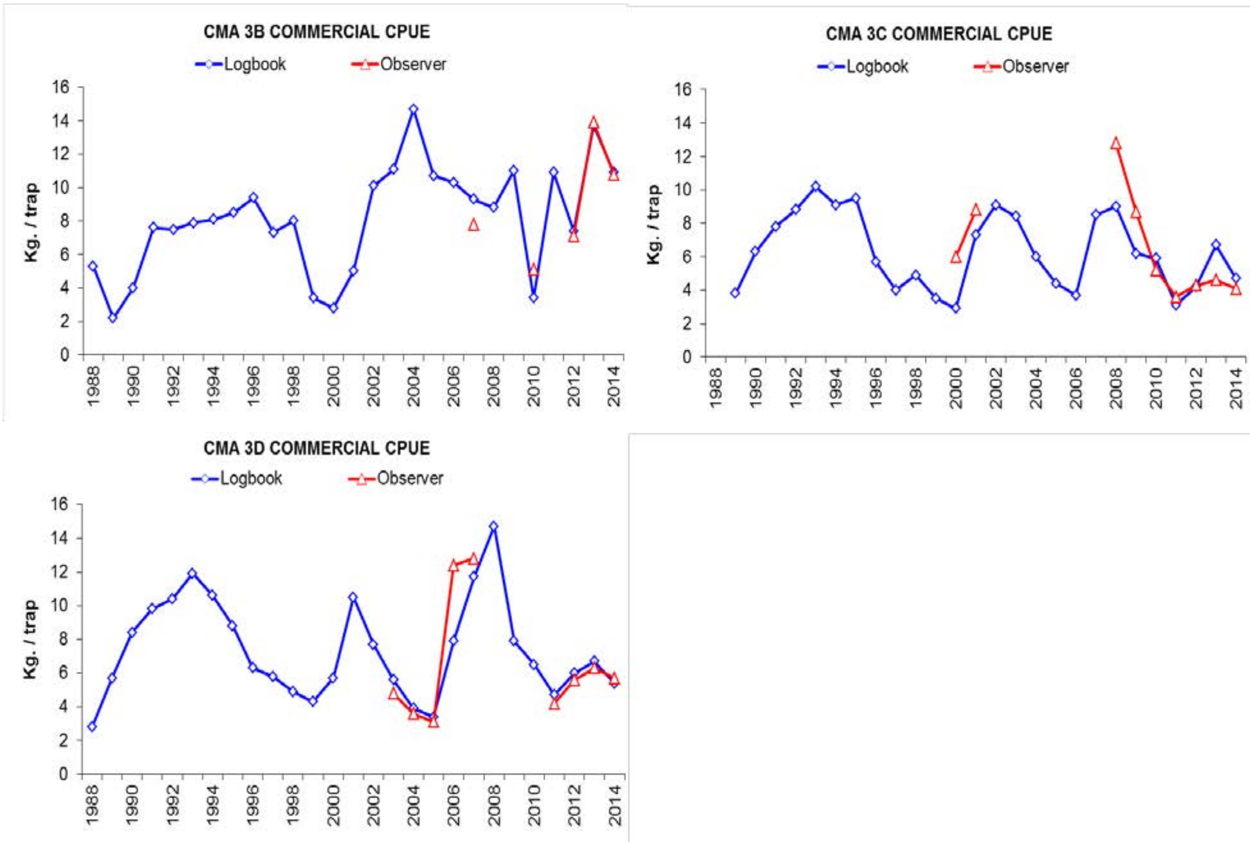


Figure 76: Trends in Div. 3K inshore logbook CPUE and observer CPUE by CMAs. 2014 logbook CPUE preliminary.

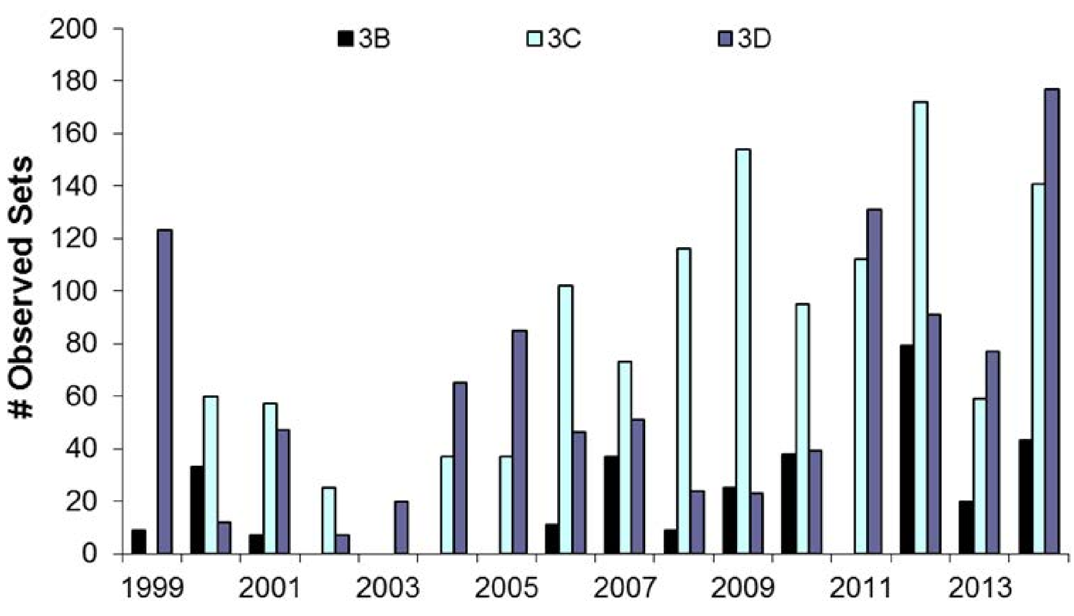


Figure 77: Trends in number of observed sets by CMAs and year in Div. 3K inshore.

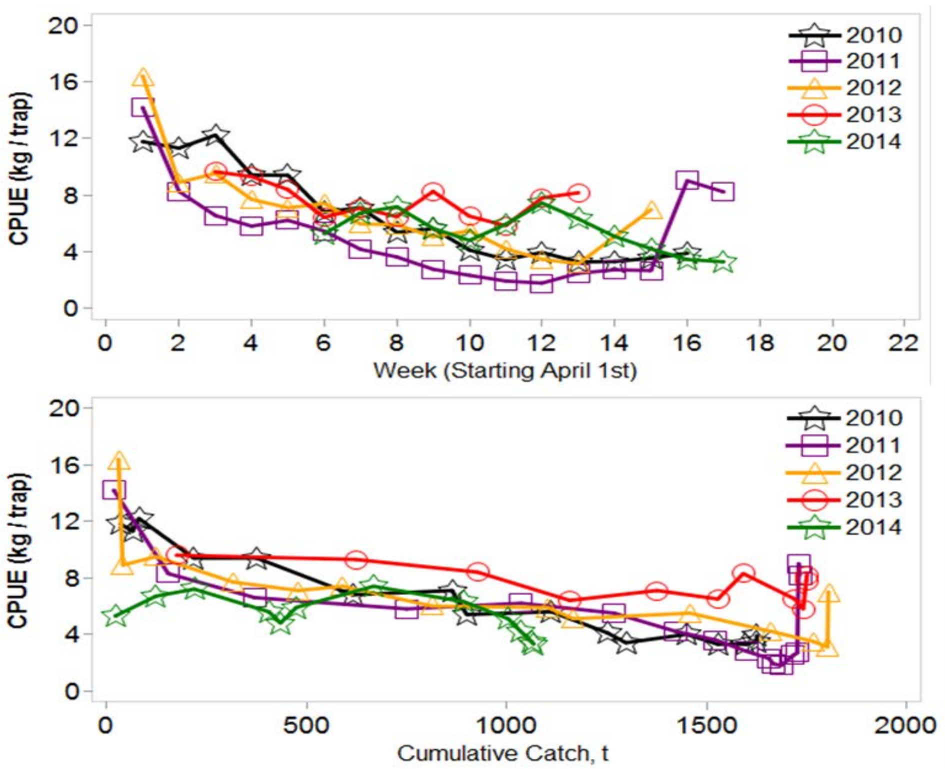


Figure 78: Seasonal trends in logbook-based CPUE for Div. 3K inshore; by week (above), and in relation to cumulative catch (below).

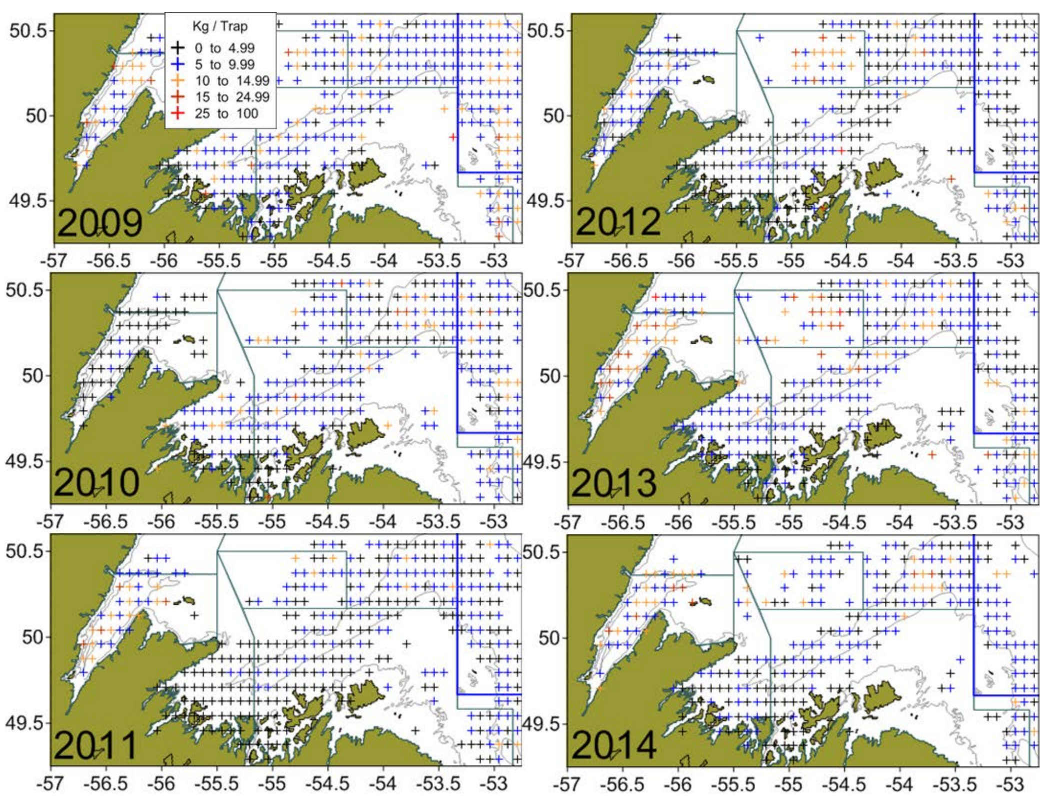


Figure 79: Spatial distribution of Div. 3K inshore logbook CPUE by year.

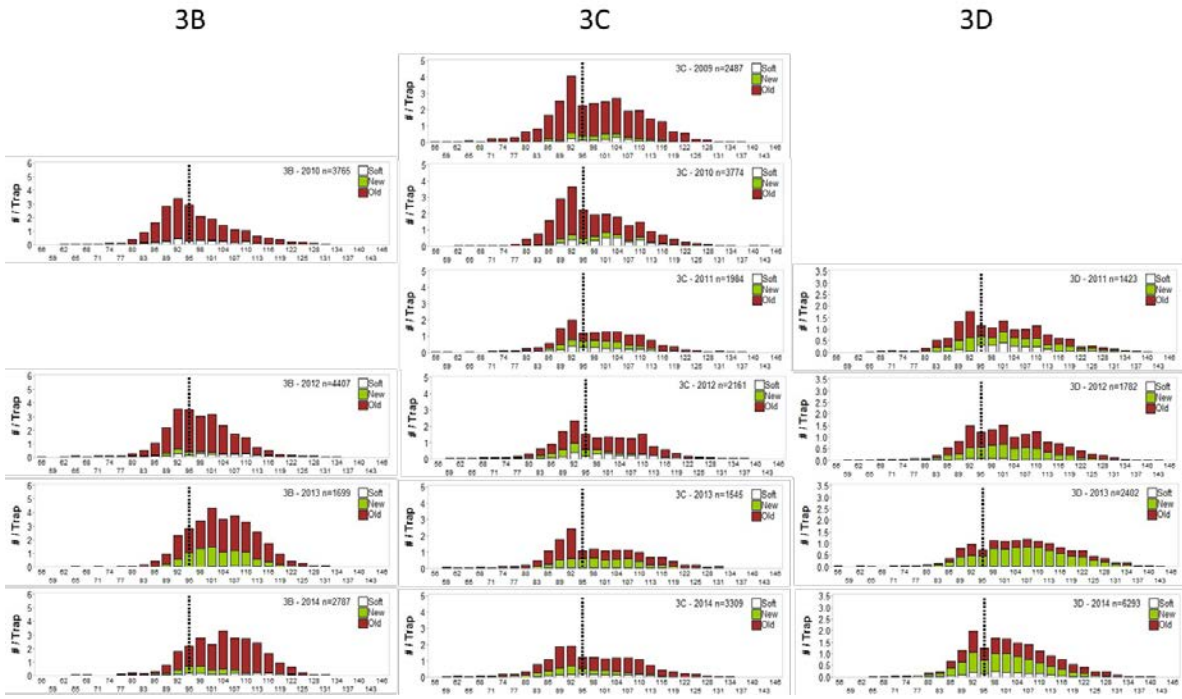


Figure 80: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Div. 3K inshore CMAs. The vertical dashed line indicates the minimum legal size.

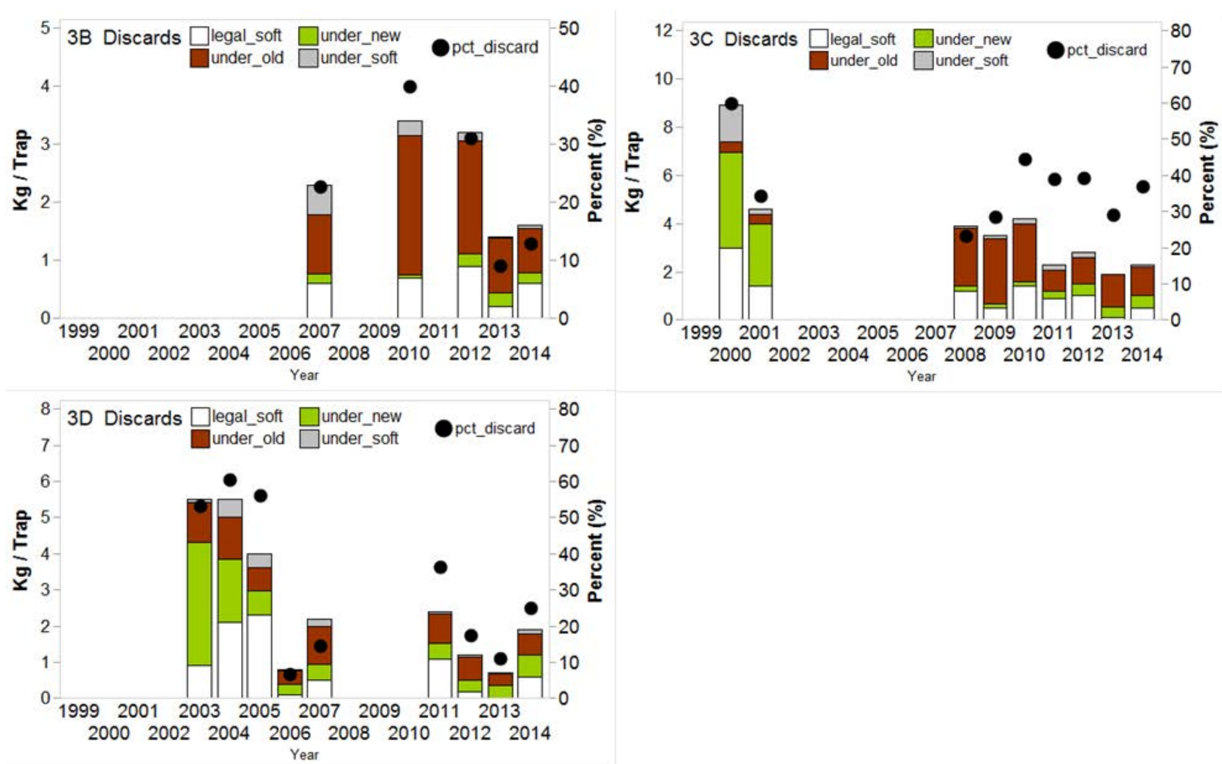


Figure 81: Trends in observed catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded, in Div. 3K inshore CMAs.

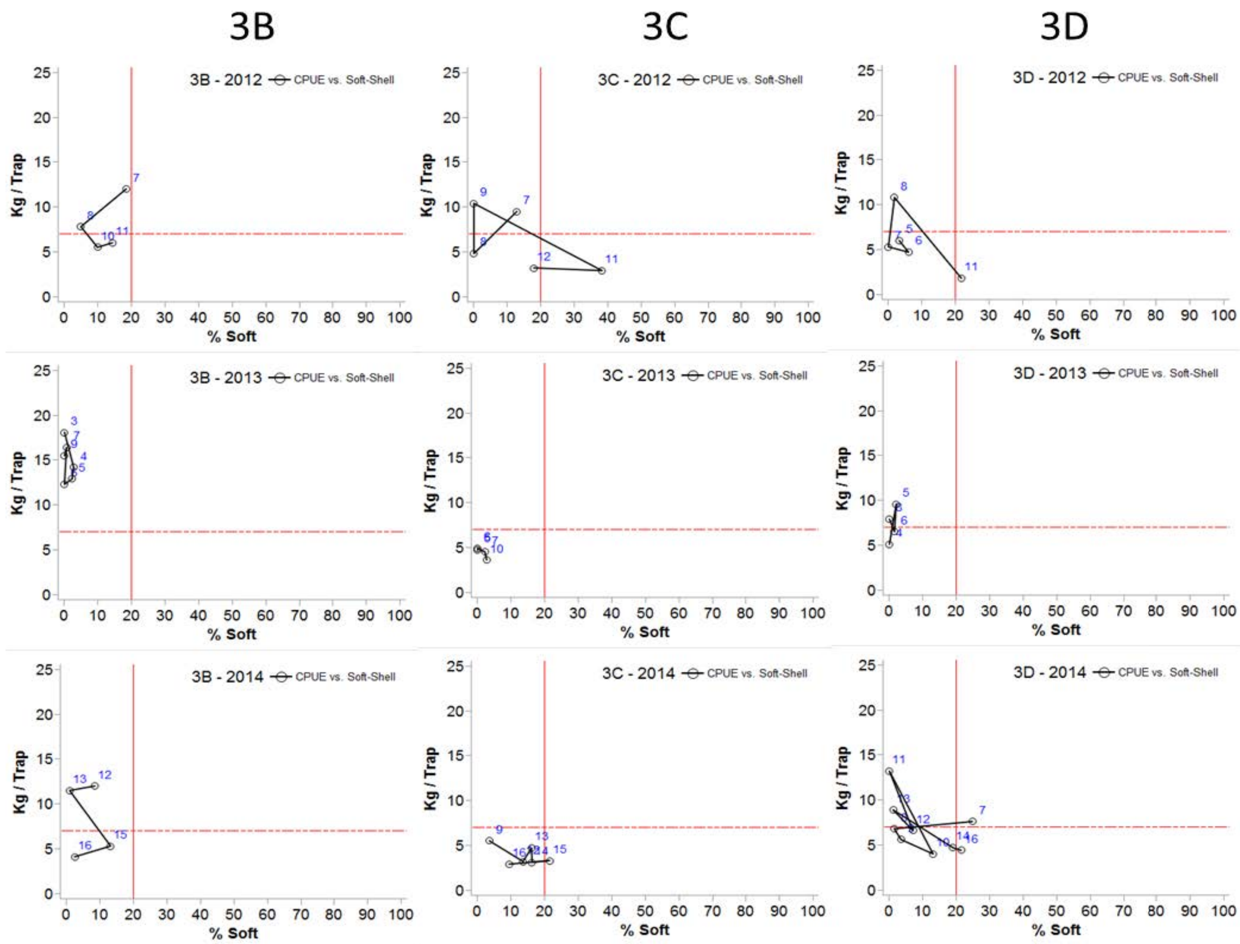


Figure 82: Trends in weekly percentages of kept vs. soft-shell crab in the Div. 3K inshore fishery CMAs from observer at-sea sampling.

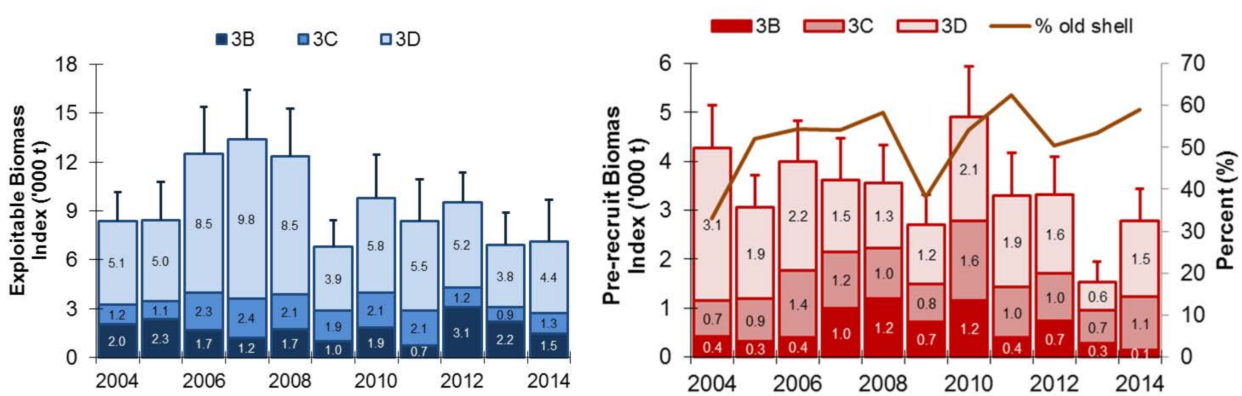


Figure 83: Div. 3K inshore exploitable (left) and pre-recruit (right) biomass indices by CMA (left) from the CPS trap survey. The brown line on the pre-recruit plot represents the percentage of sub-legal-sized crabs that were old-shelled.

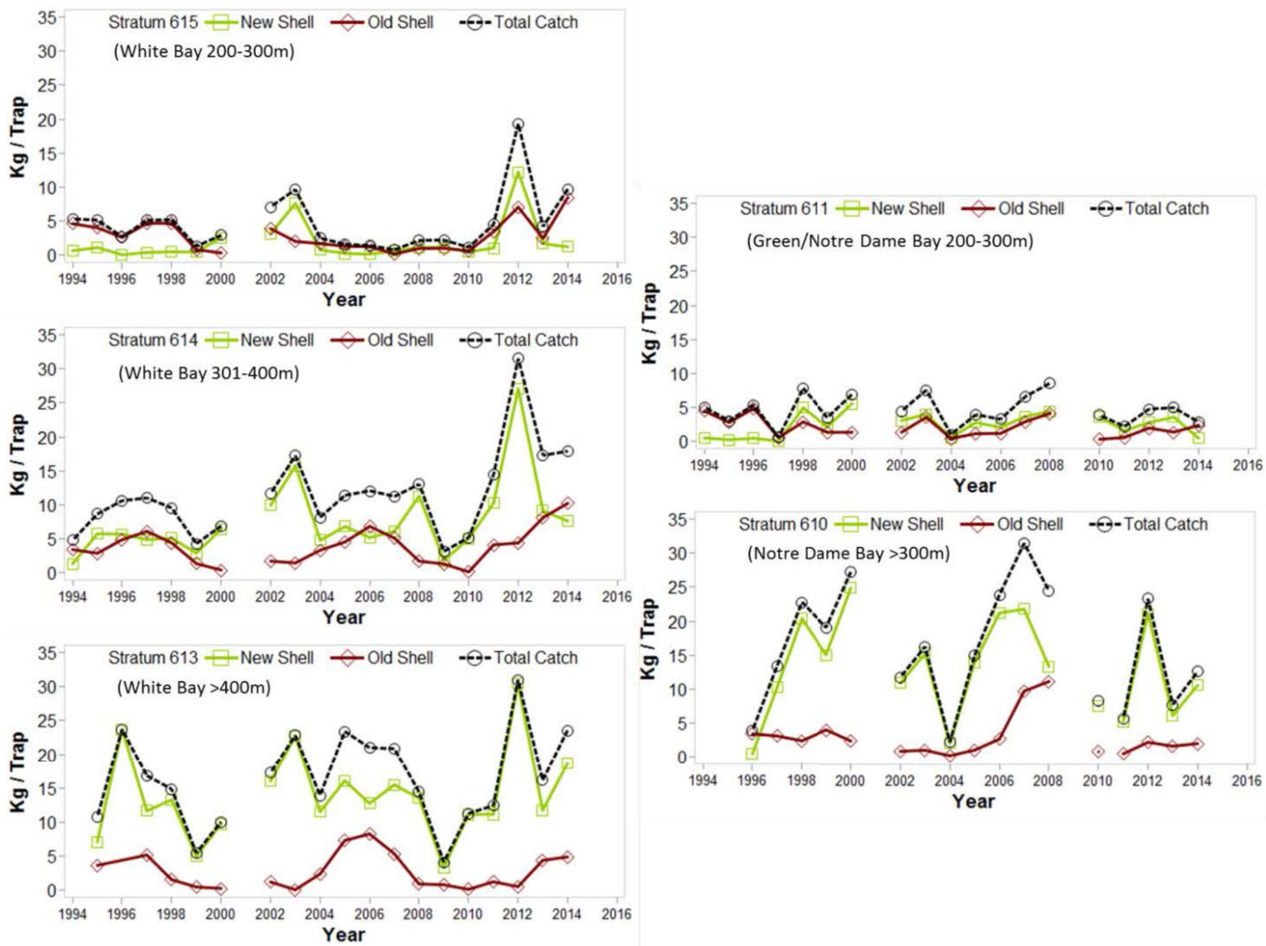


Figure 84: Trends in CPUE by shell condition for legal-sized crabs from strata occupied in the DFO trap survey in Div. 3K inshore. No survey was conducted in 2001 and 2009 was incomplete in Green and Notre Dame Bays.

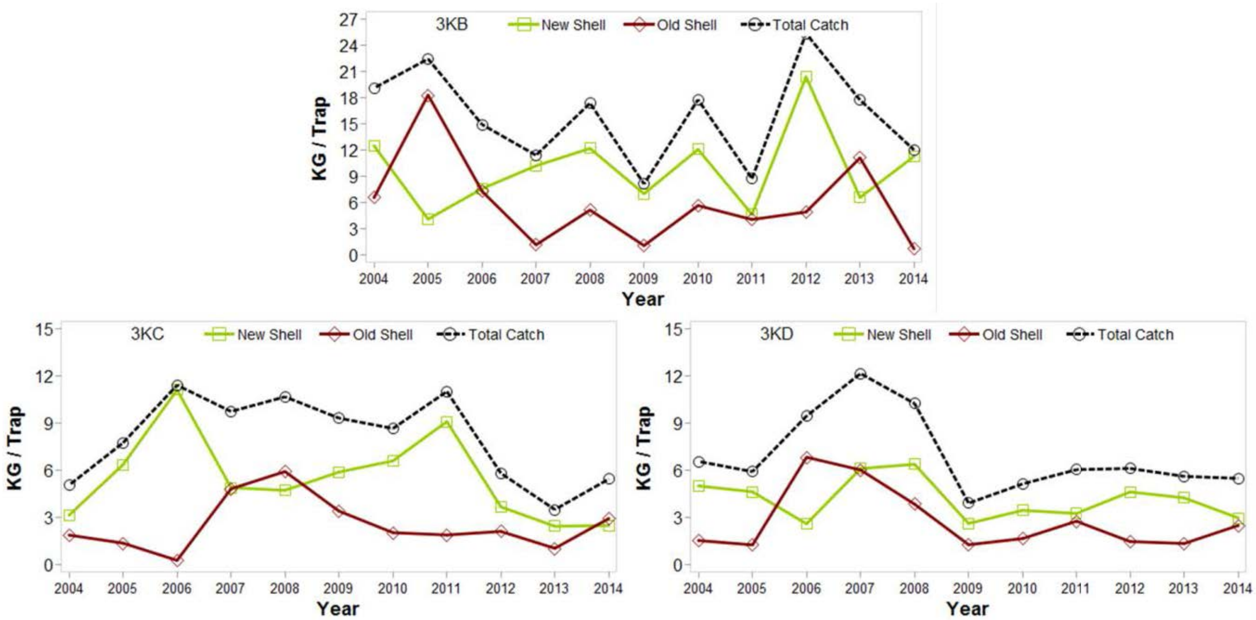


Figure 85: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in Div. 3K inshore CMAs.

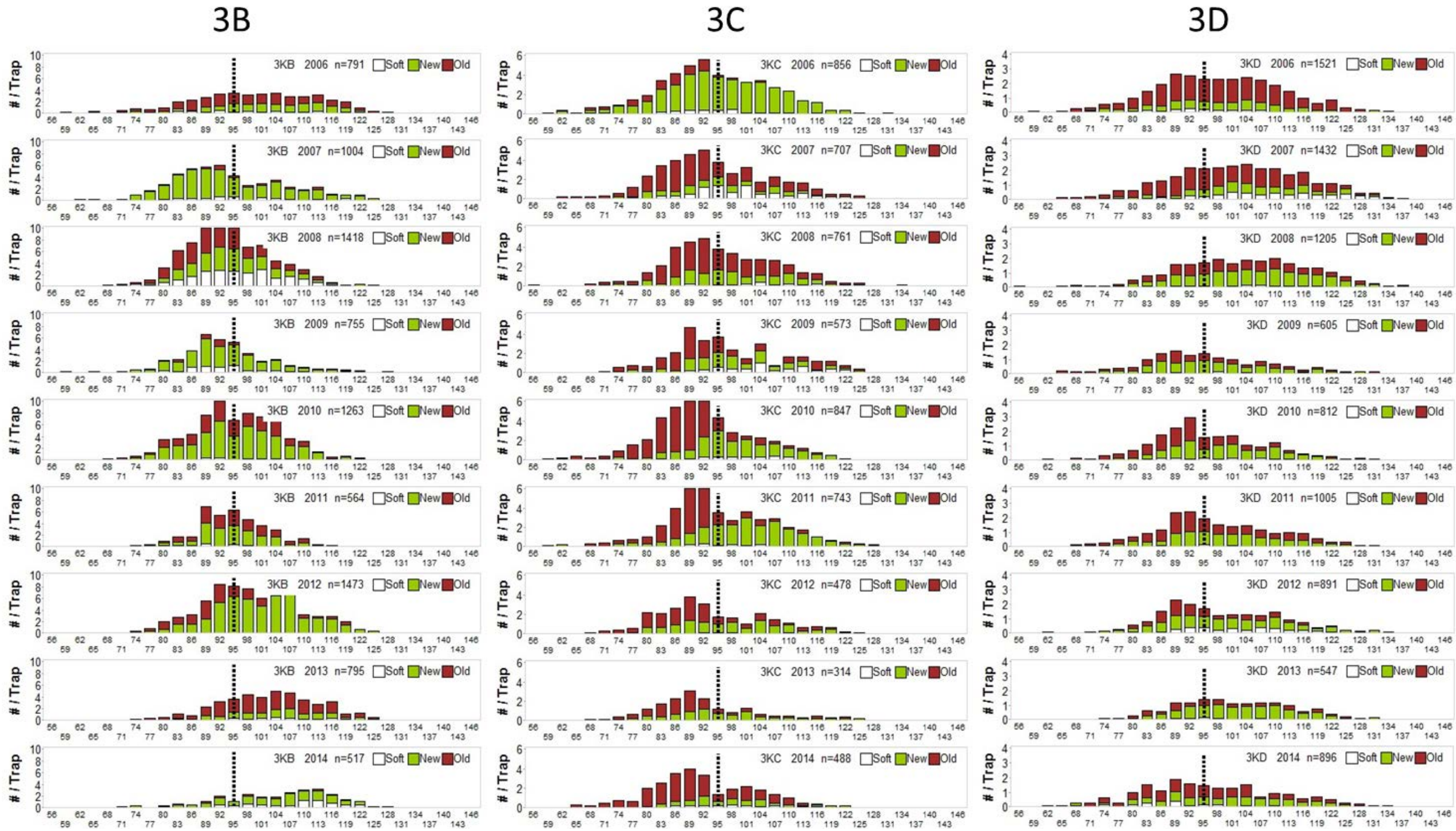


Figure 86: Trends in male carapace width distributions from core stations in the Div. 3K inshore CPS trap survey by CMA. The vertical dashed line indicates the minimum legal size.

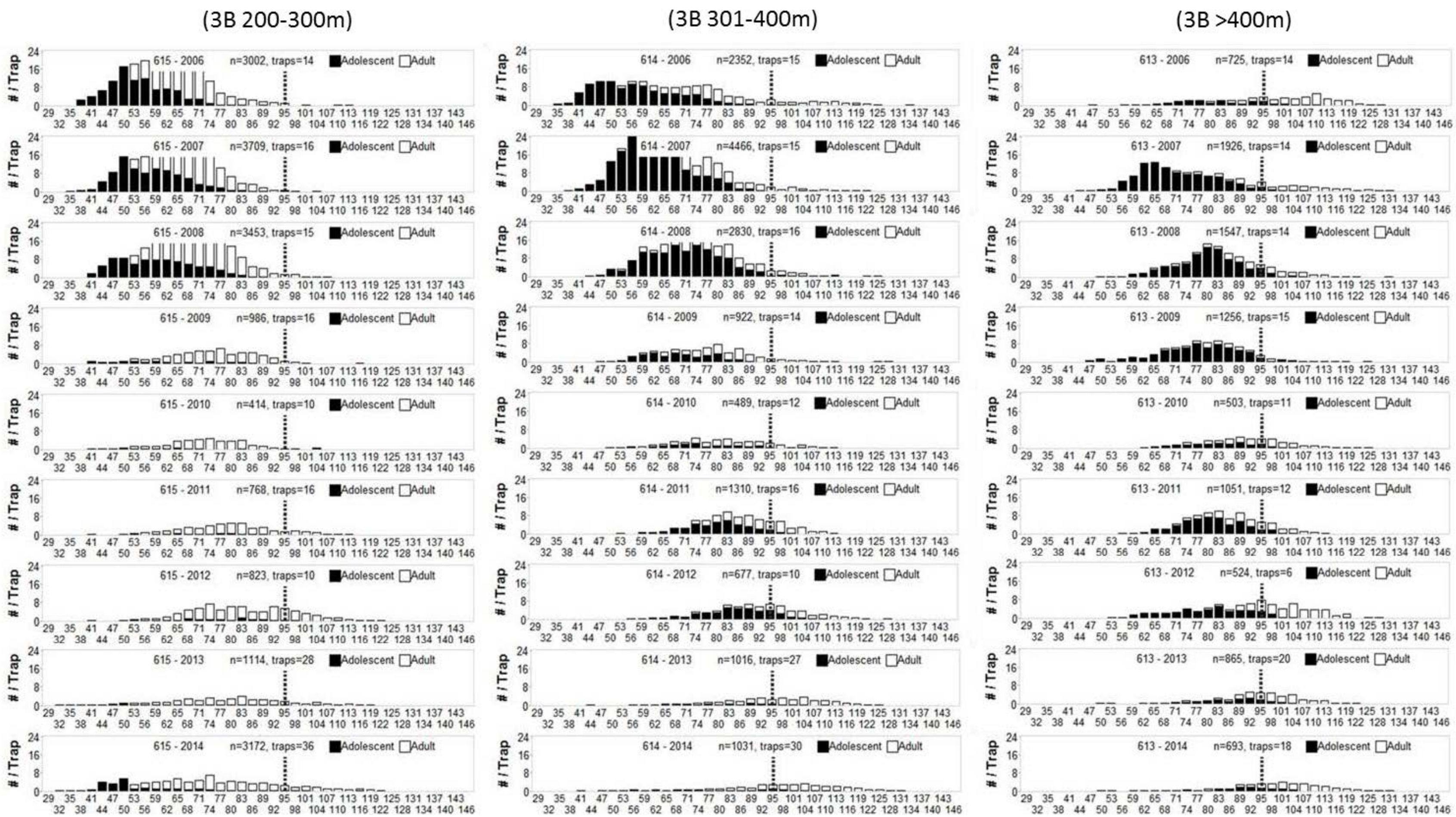


Figure 87: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in DFO trap survey in White Bay (CMA 3B). The vertical dashed line indicates the minimum legal size.

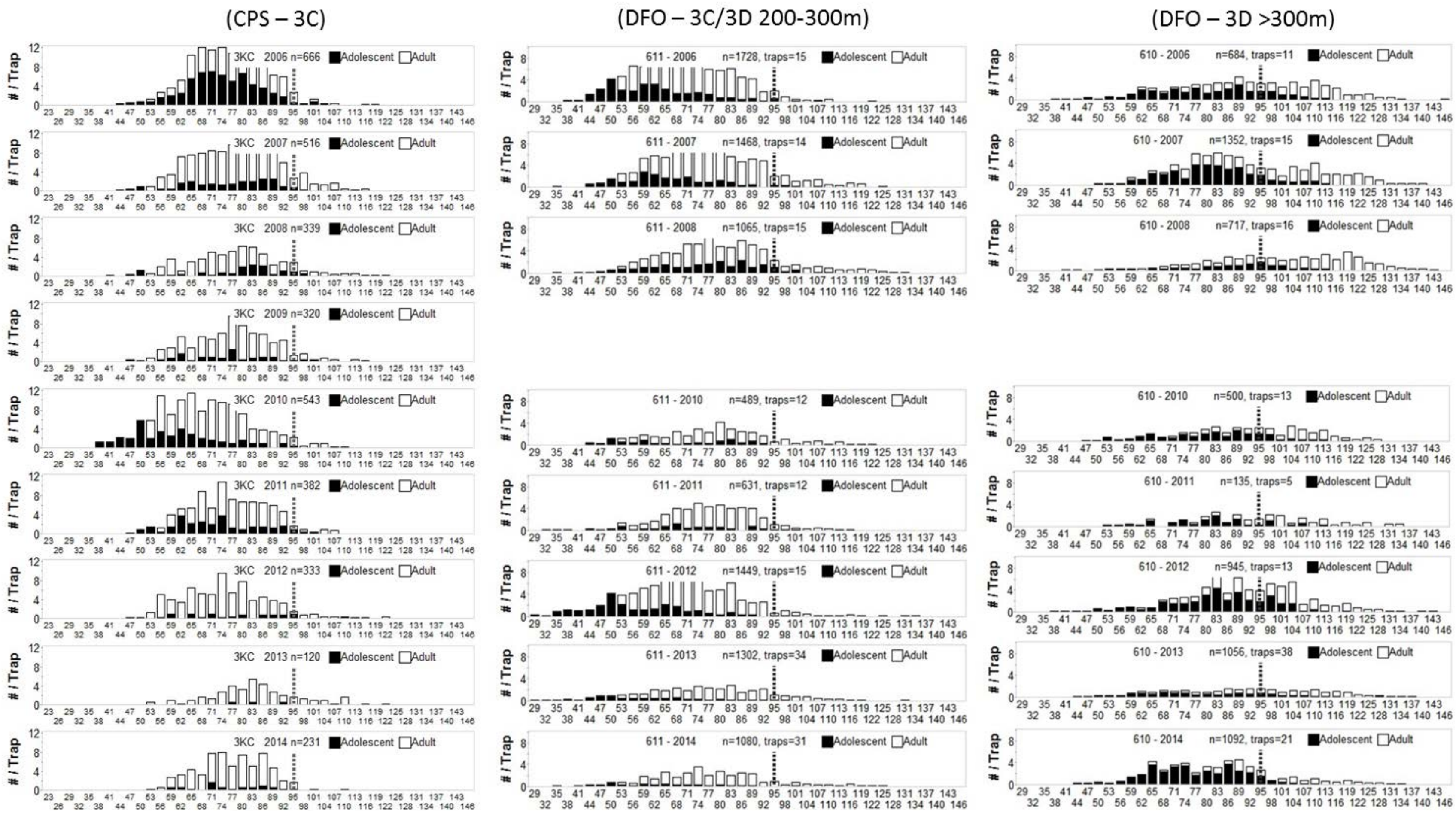


Figure 88: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in DFO and CPS trap surveys in Green Bay (CMA 3C) and Notre Dame Bay (CMA3D). The vertical dashed line indicates the minimum legal size.

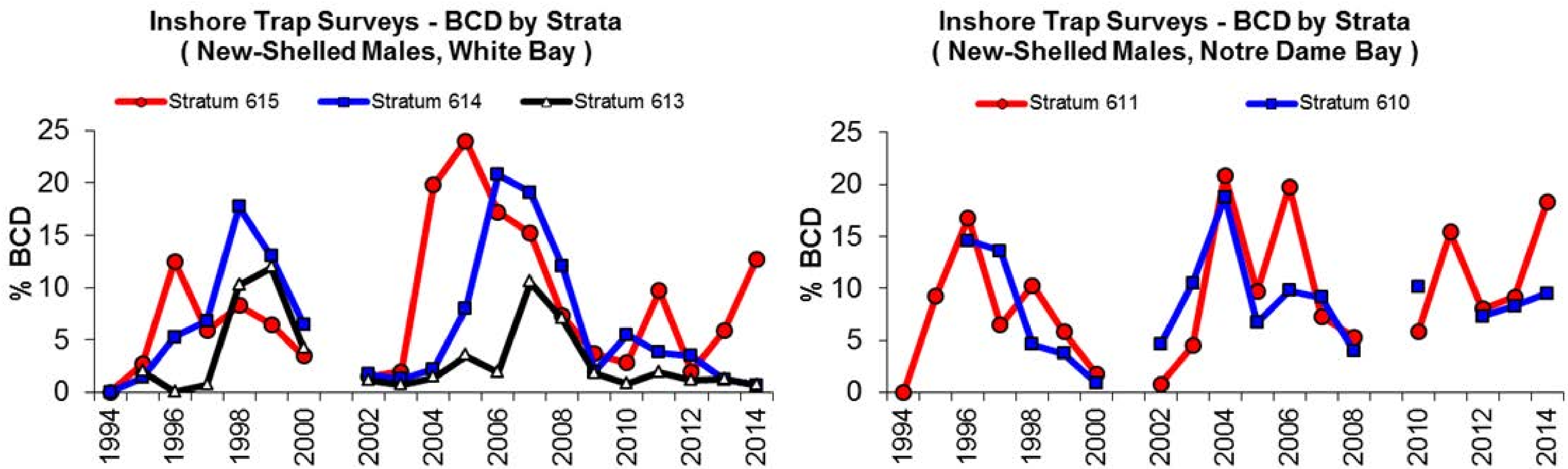


Figure 89: Prevalence of BCD in new-shelled males from Div. 3K DFO inshore trap surveys by stratum in White Bay (CMA 3B) and Notre Dame Bay (CMA 3D).

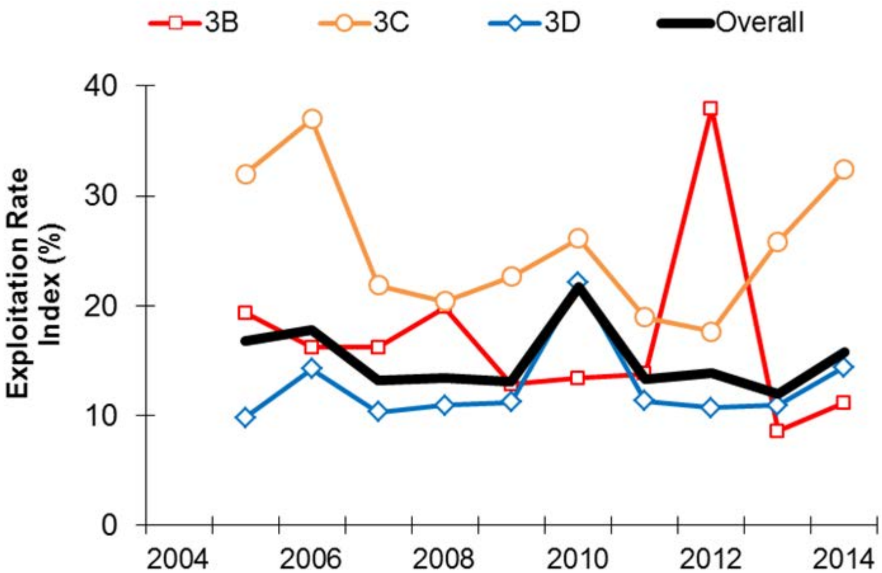


Figure 90: Exploitation rate indices by CMA as well as overall for Div. 3K inshore based on the CPS trap survey.

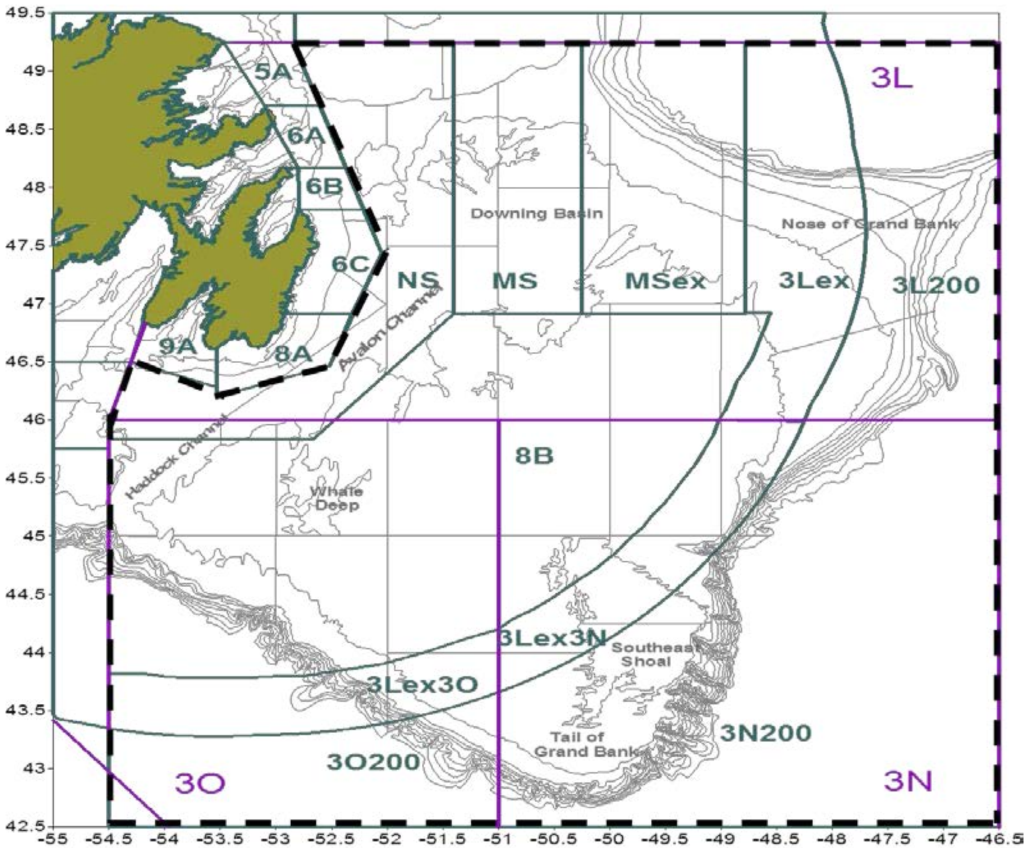


Figure 91: Map of Divs. 3LNO showing CMAs and important bathymetric features. Dashed perimeter indicates offshore areas.

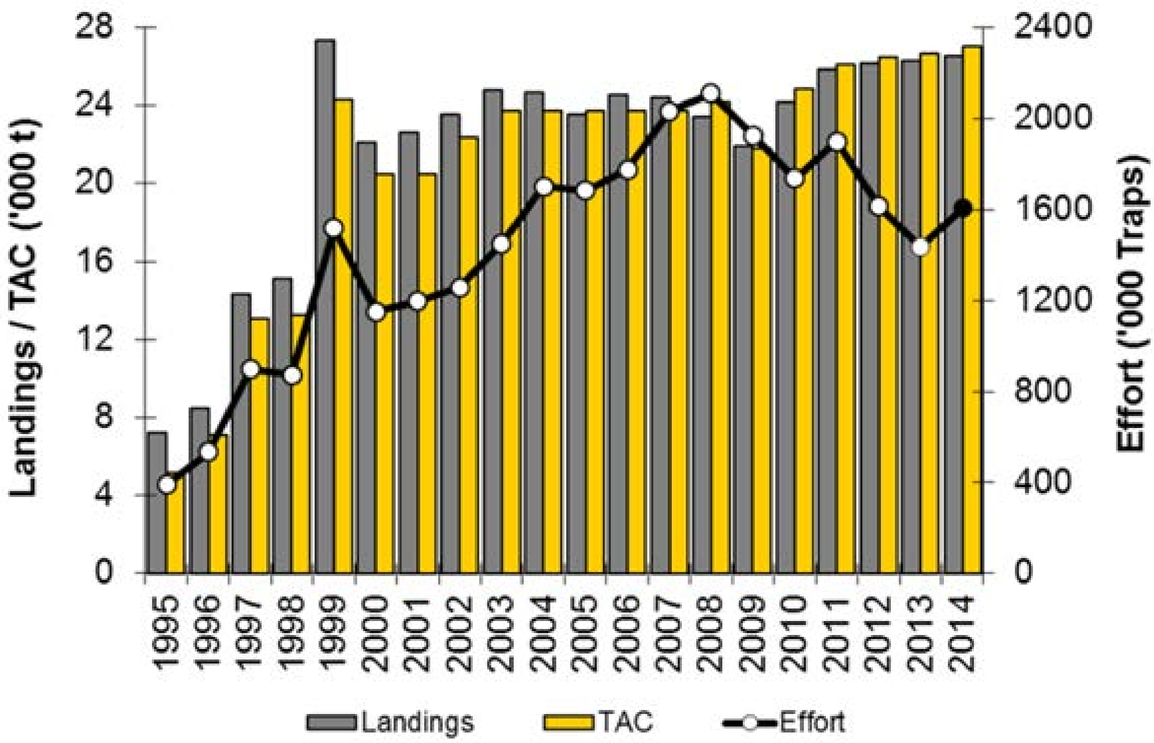


Figure 92: Trends in Divs. 3LNO offshore landings, TAC, and fishing effort. 2014 effort preliminary.

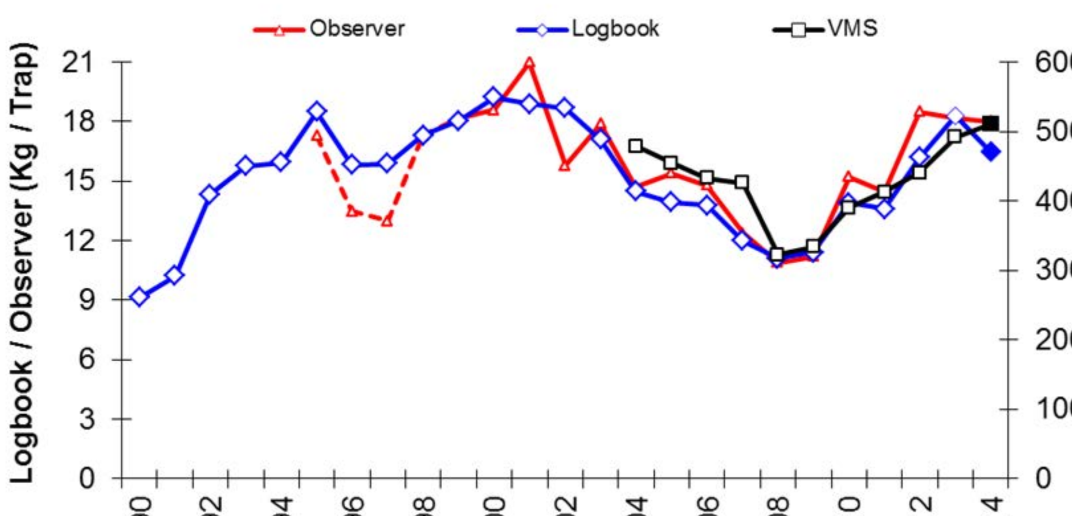


Figure 93: Trends in commercial logbook-based, observer-based, and VMS-based CPUE in the Divs. 3LNO offshore fishery. 2014 logbook and VMS CPUE estimates preliminary.

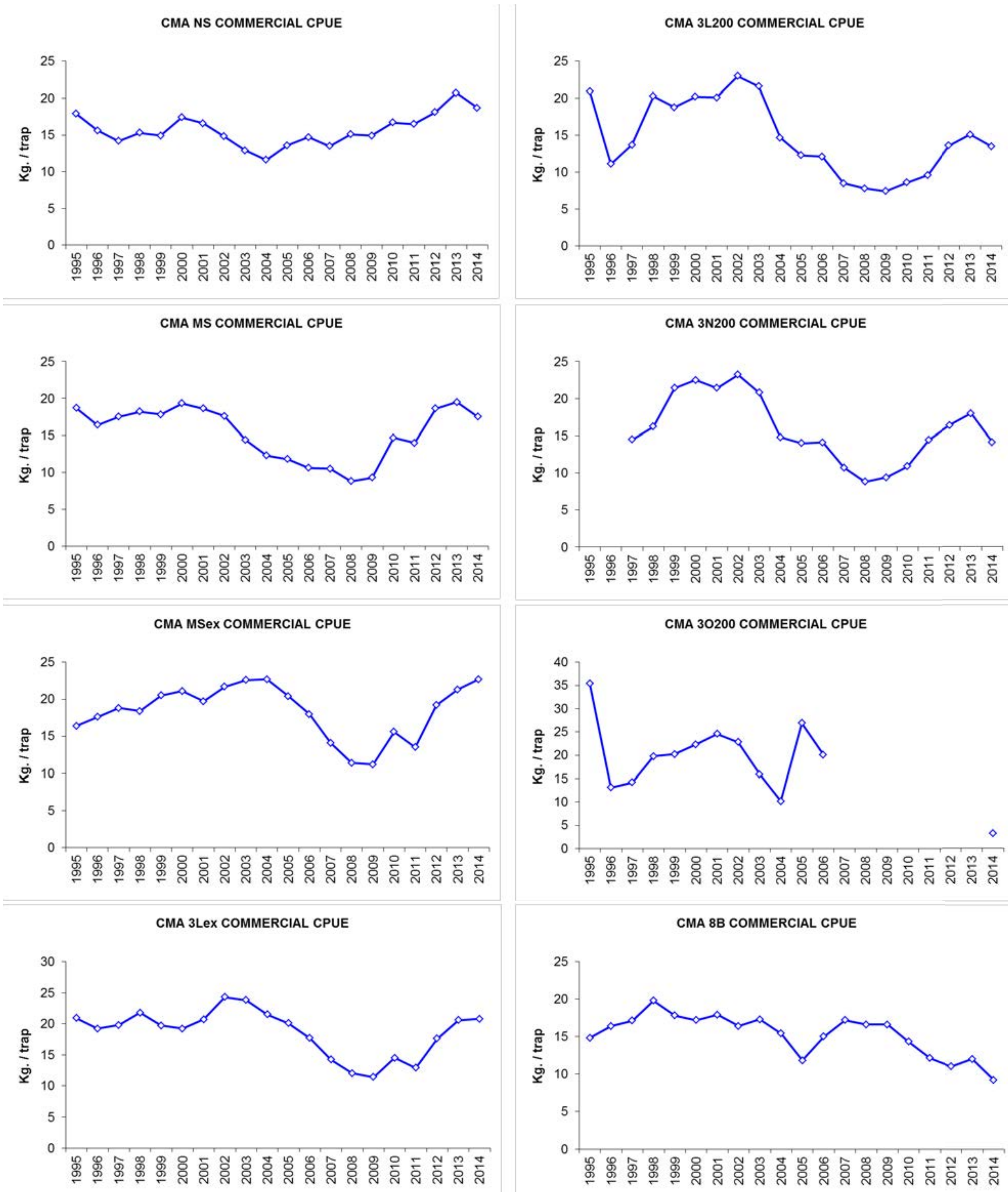


Figure 94: Trends in Divs. 3LNO offshore logbook CPUE by CMA. 2014 logbook CPUE preliminary.

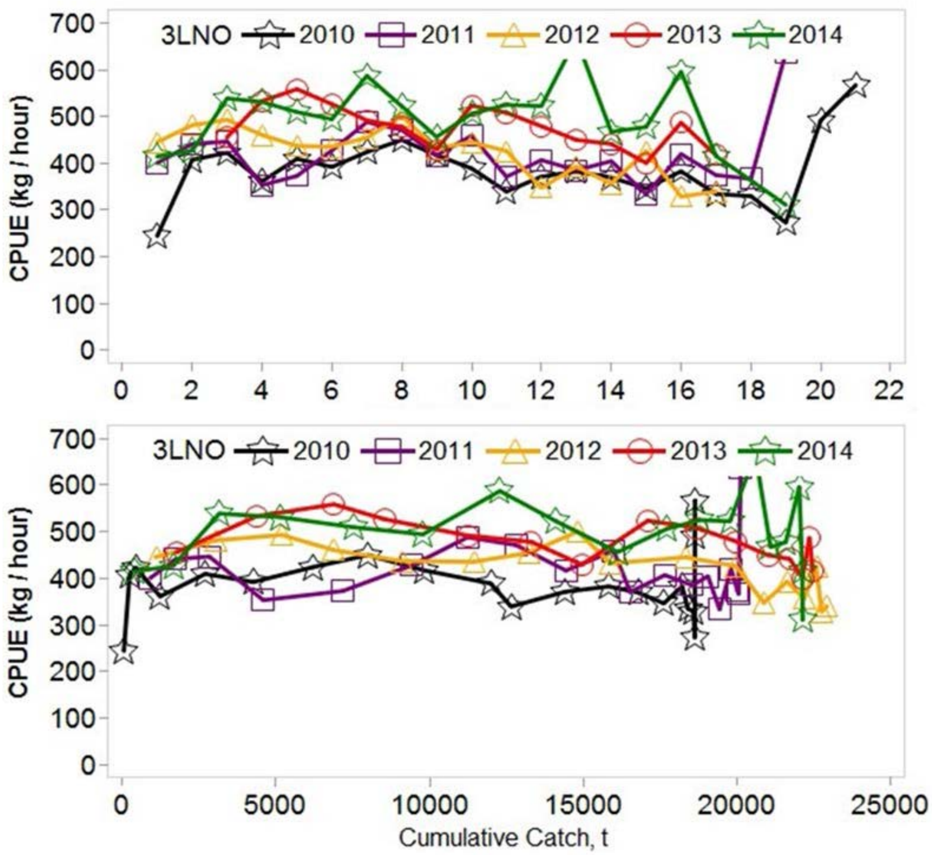


Figure 95: Seasonal trends in VMS-based CPUE for Divs. 3LNO offshore; by week (above), and in relation to cumulative catch (below).

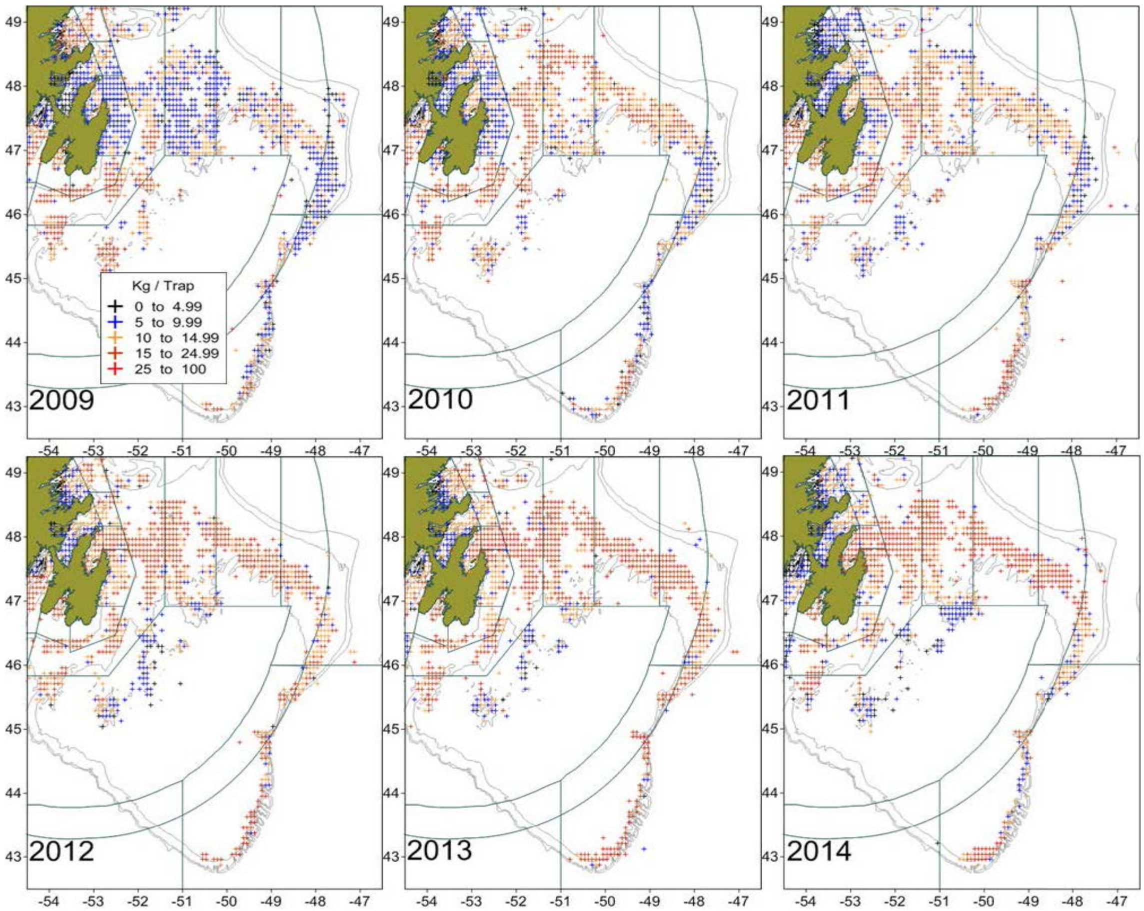


Figure 96: Spatial distribution of Divs. 3LNO logbook CPUE by year.

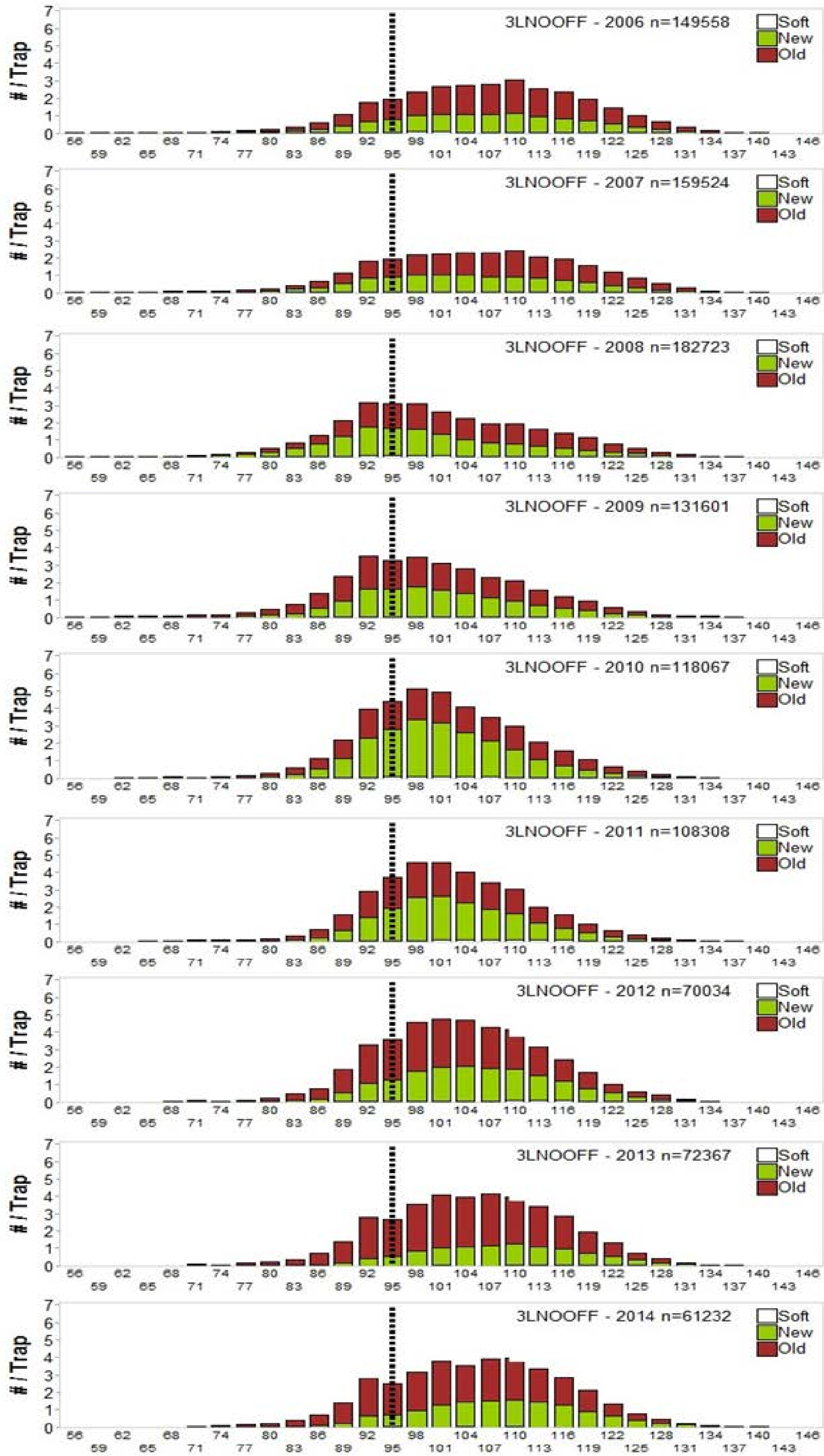


Figure 97: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Divs. 3LNO offshore. The vertical dashed line indicates the minimum legal size.

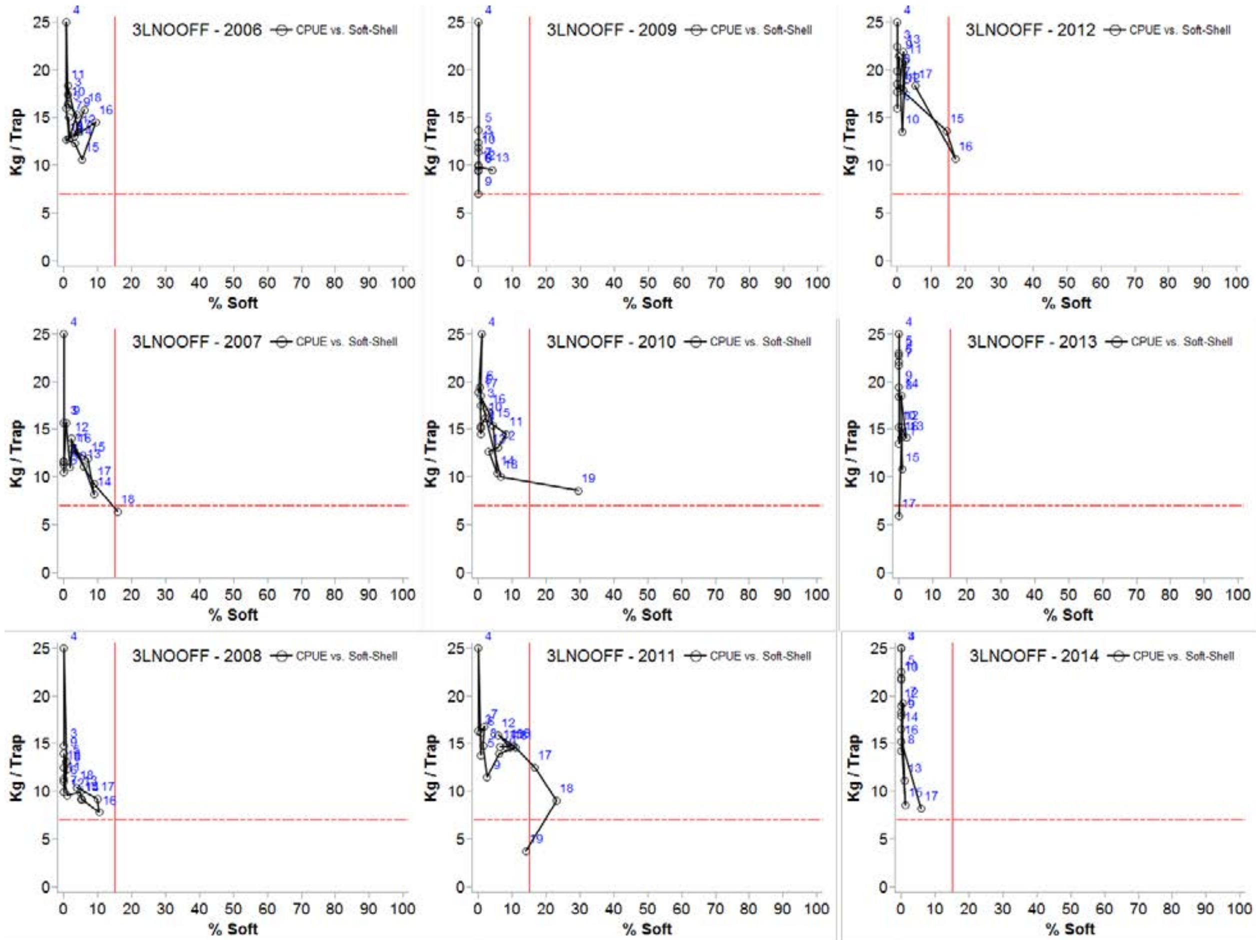


Figure 98: Trends in weekly percentages of kept vs. soft-shell crab in Divs. 3LNO offshore fishery from at-sea sampling by observers.

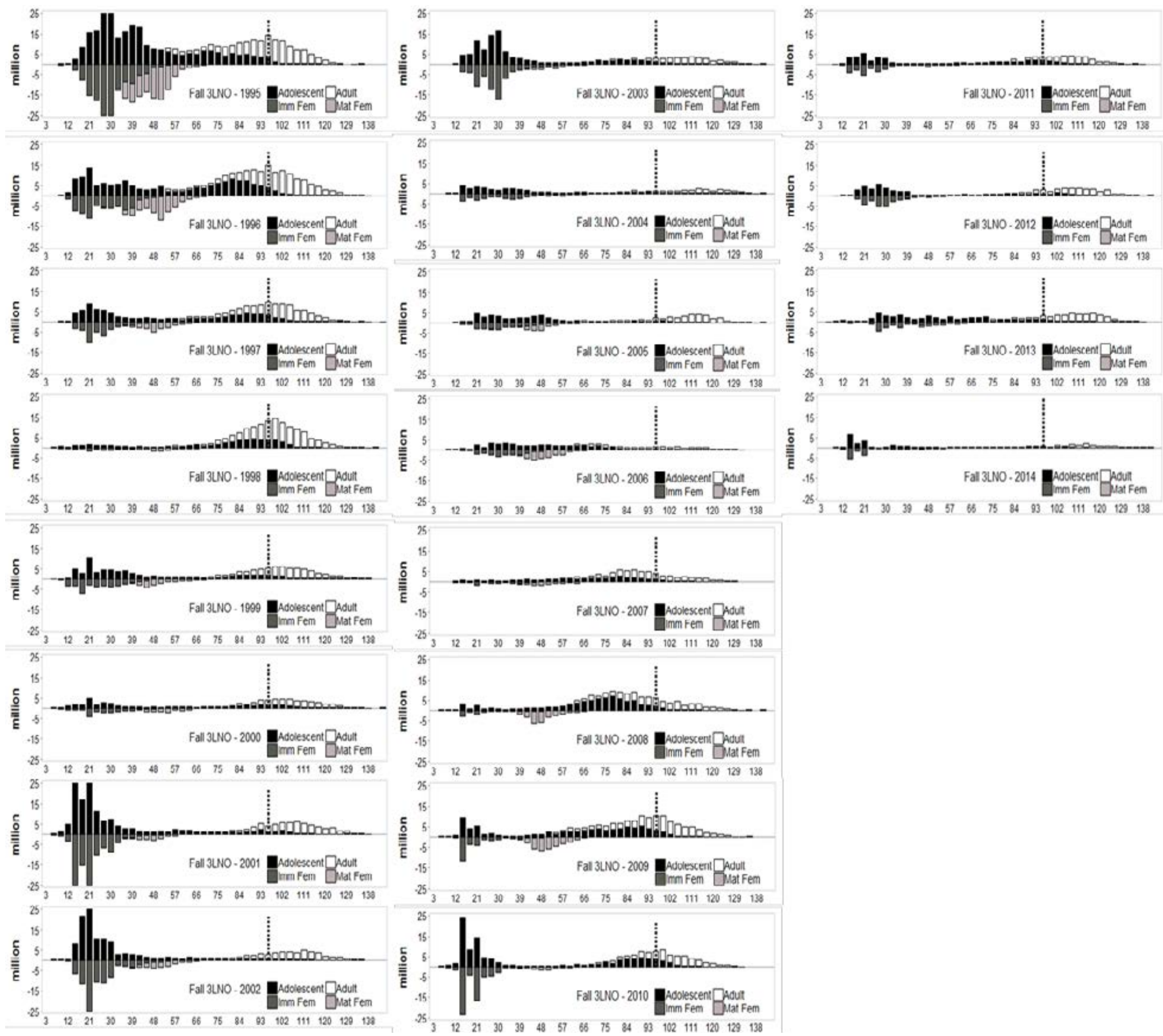


Figure 99: Abundance indices by carapace width for Divs. 3LNO offshore juveniles plus adolescent males (dark bars), adult males (white bars), immature females (dark grey bars) and mature females (light grey bars) from fall trawl surveys.

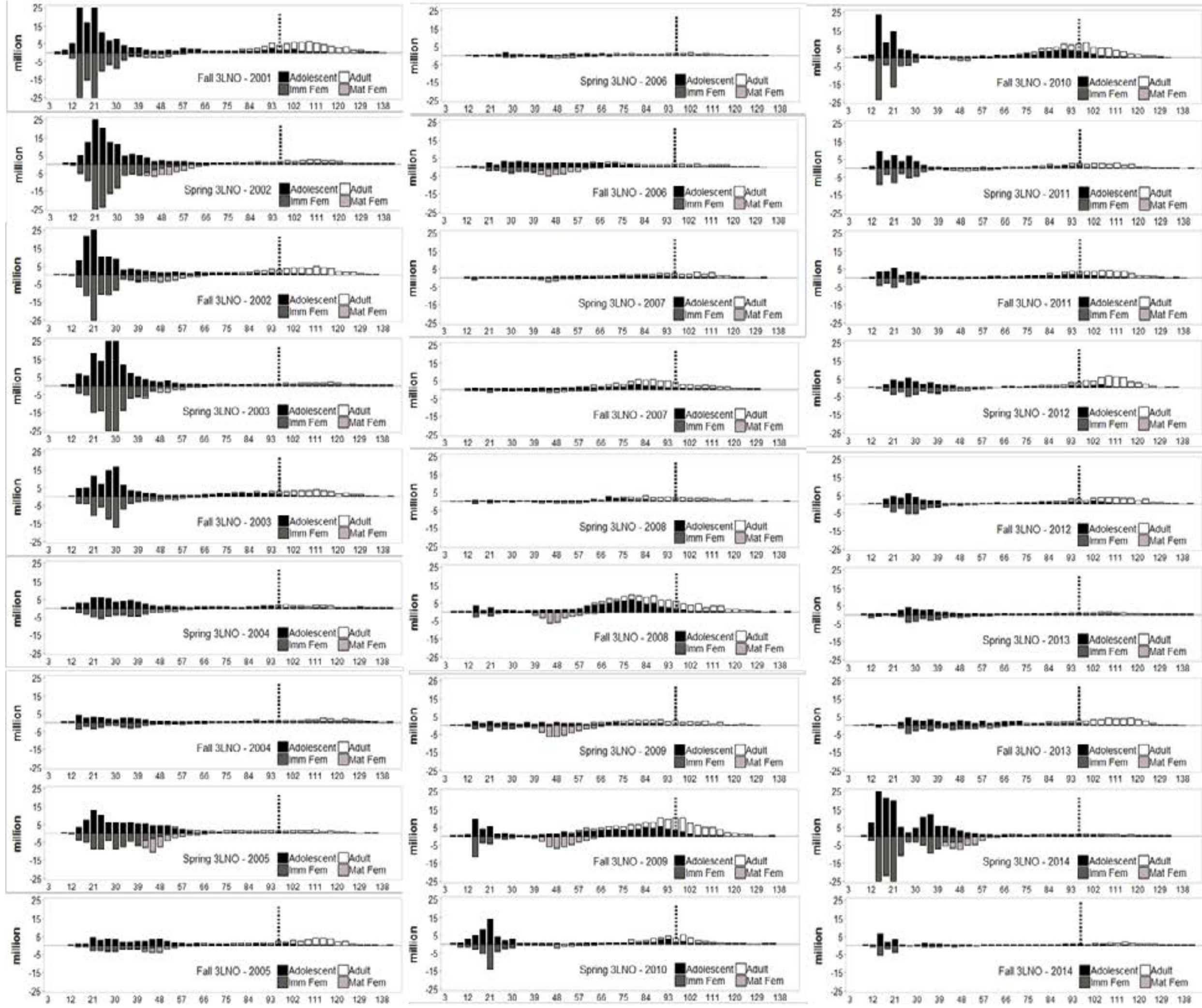


Figure 100: Abundance indices by carapace width for Divs. 3LNO offshore juveniles plus adolescent males (dark bars), adult males (white bars), immature females (dark grey bars) and mature females (light grey bars) from spring and fall trawl surveys.

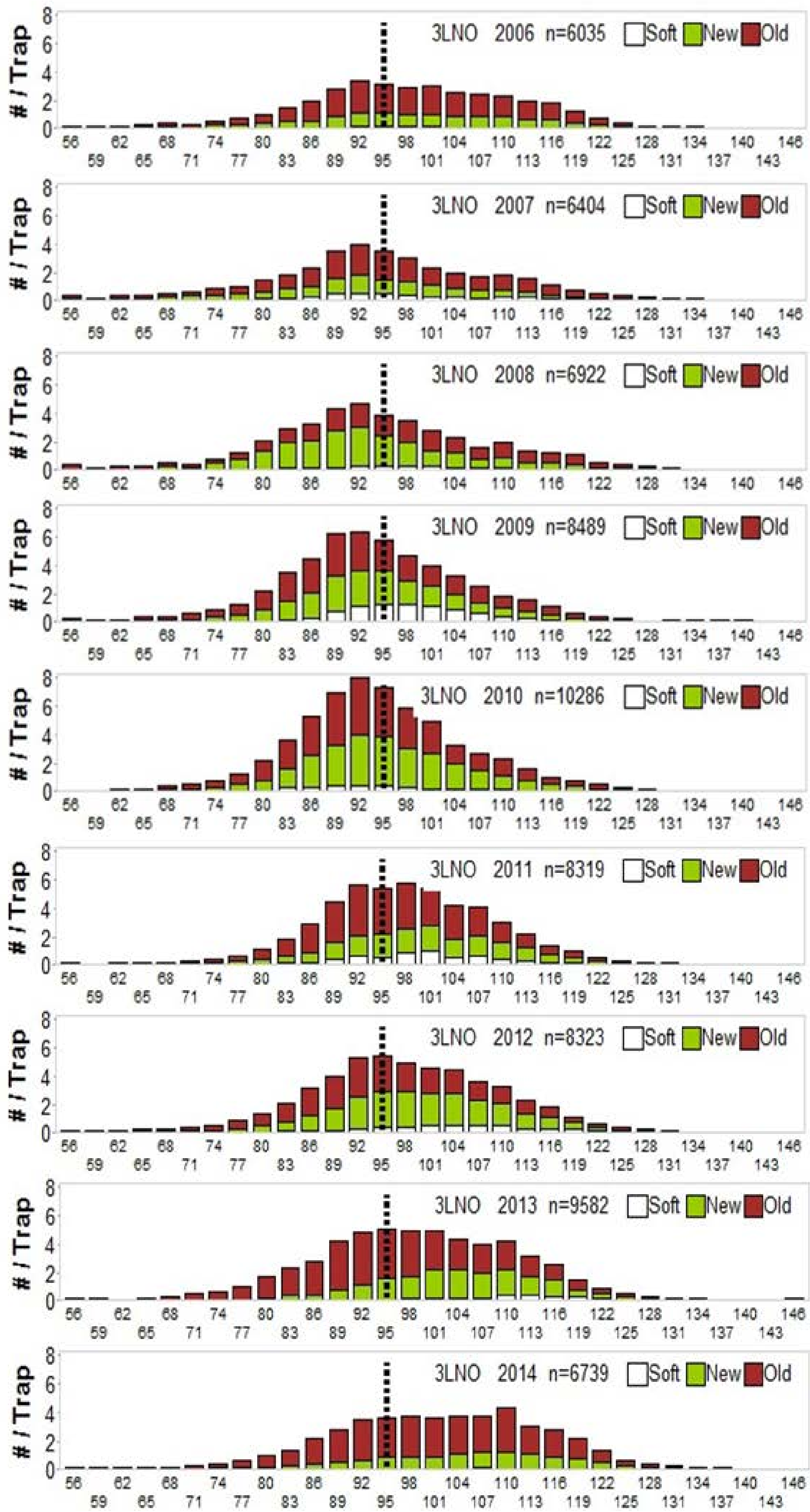


Figure 101: Trends in male carapace width distributions from large mesh traps at core stations in the Divs. 3LNO offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

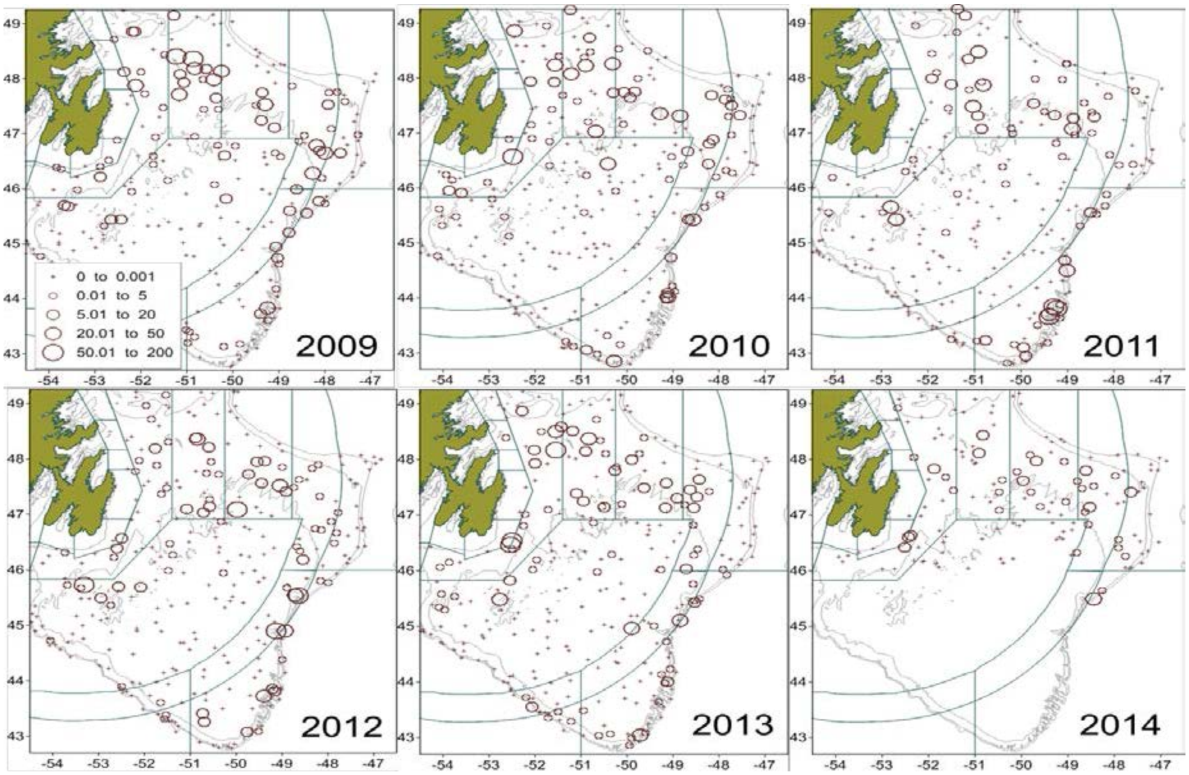


Figure 102: Spatial distribution of catches (#/tow) of exploitable males (> 94 mm CW adults) from Divs. 3LNO fall offshore trawl surveys from 2009-14.

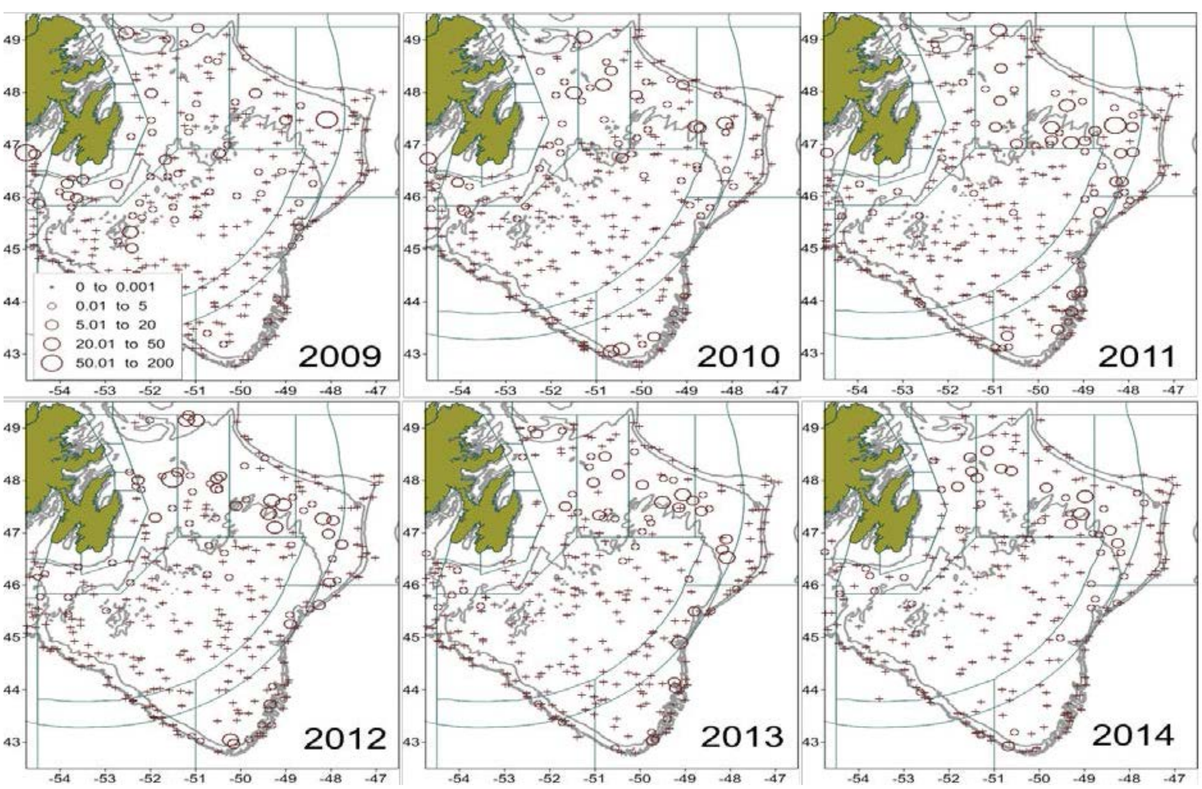


Figure 103: Spatial distribution of catches (#/tow) of exploitable males (> 94 mm CW adults) from Divs. 3LNO spring offshore trawl surveys from 2009-14.

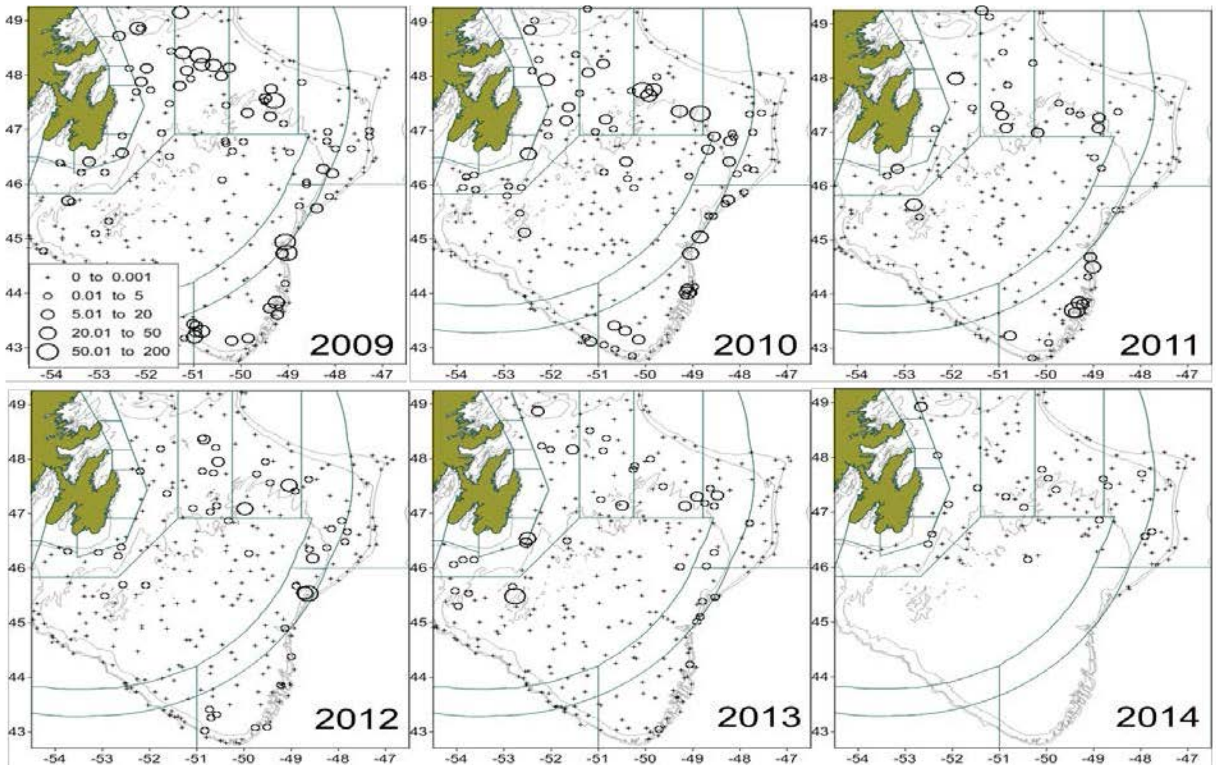


Figure 104: Spatial distribution of catches (#/tow) of pre-recruit males (> 76 mm CW adolescents) from Divs. 3LNO fall offshore trawl surveys from 2009-14.

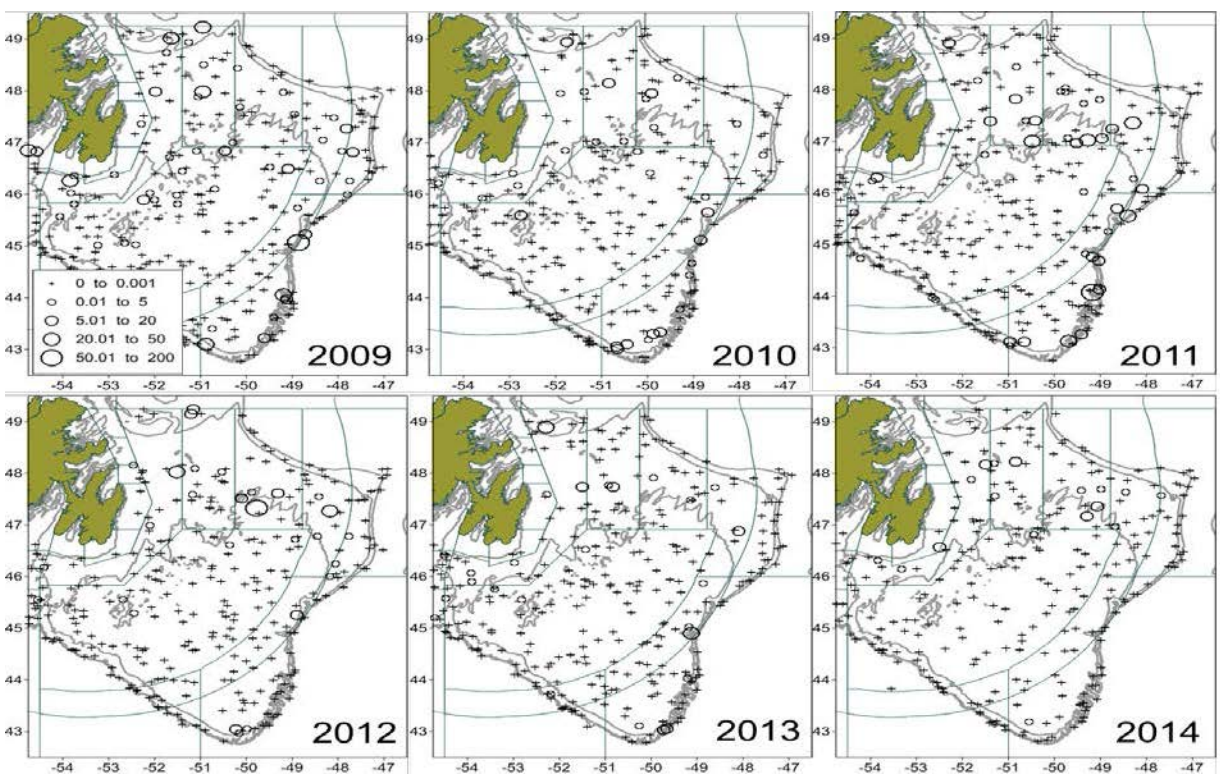


Figure 105: Spatial distribution of catches (#/tow) of pre-recruit males (> 76 mm CW adolescents) from Divs. 3LNO spring offshore trawl surveys from 2009-14.

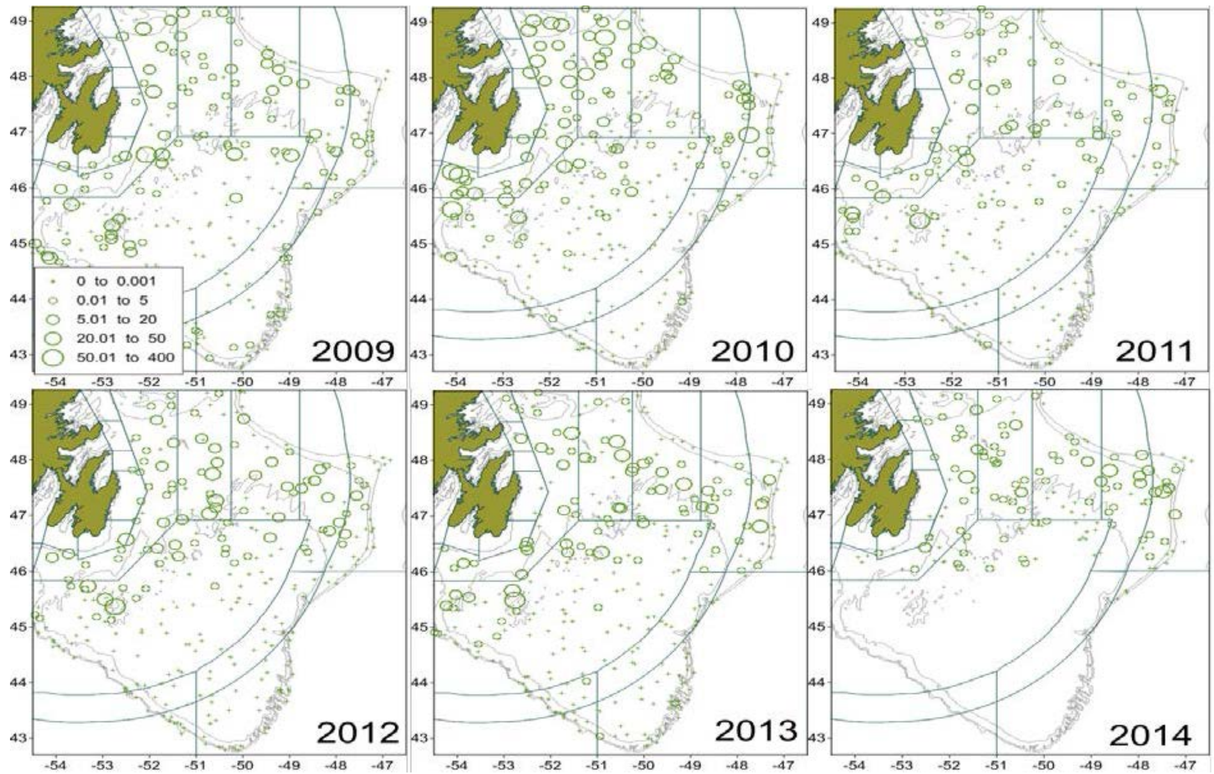


Figure 106: Spatial distribution of catches (#/tow) of small males (< 60 mm CW adolescents) from Divs. 3LNO fall offshore trawl surveys from 2009-14.

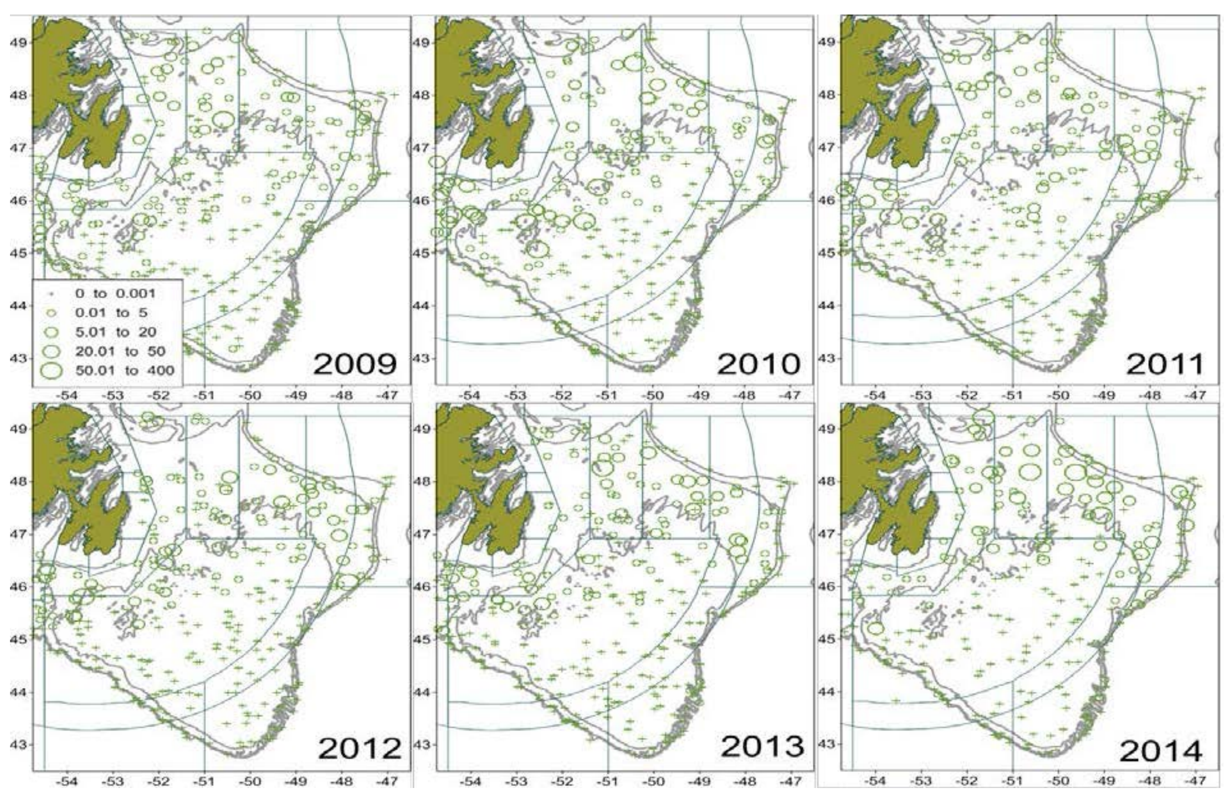


Figure 107: Spatial distribution of catches (#/tow) of small males (< 60 mm CW adolescents) from Divs. 3LNO spring offshore trawl surveys from 2009-14.

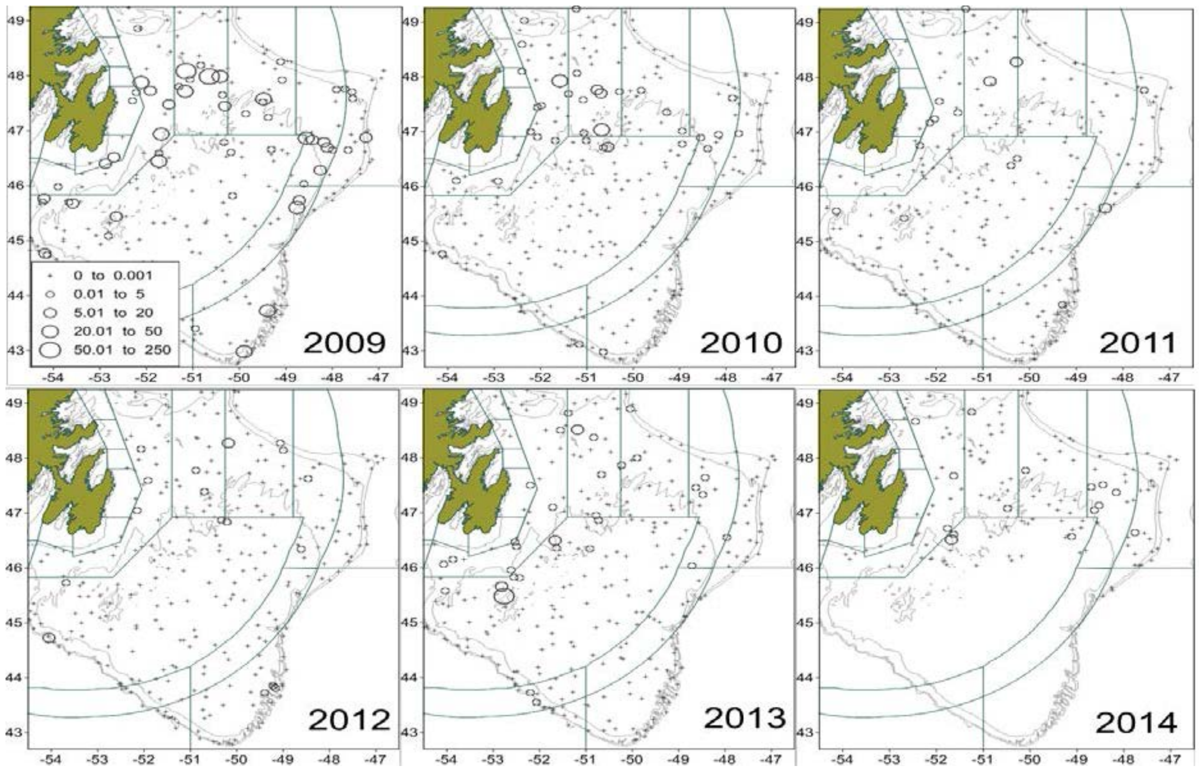


Figure 108: Spatial distribution of catches (#/tow) of mature females from Divs. 3LNO fall offshore trawl surveys from 2009-14.

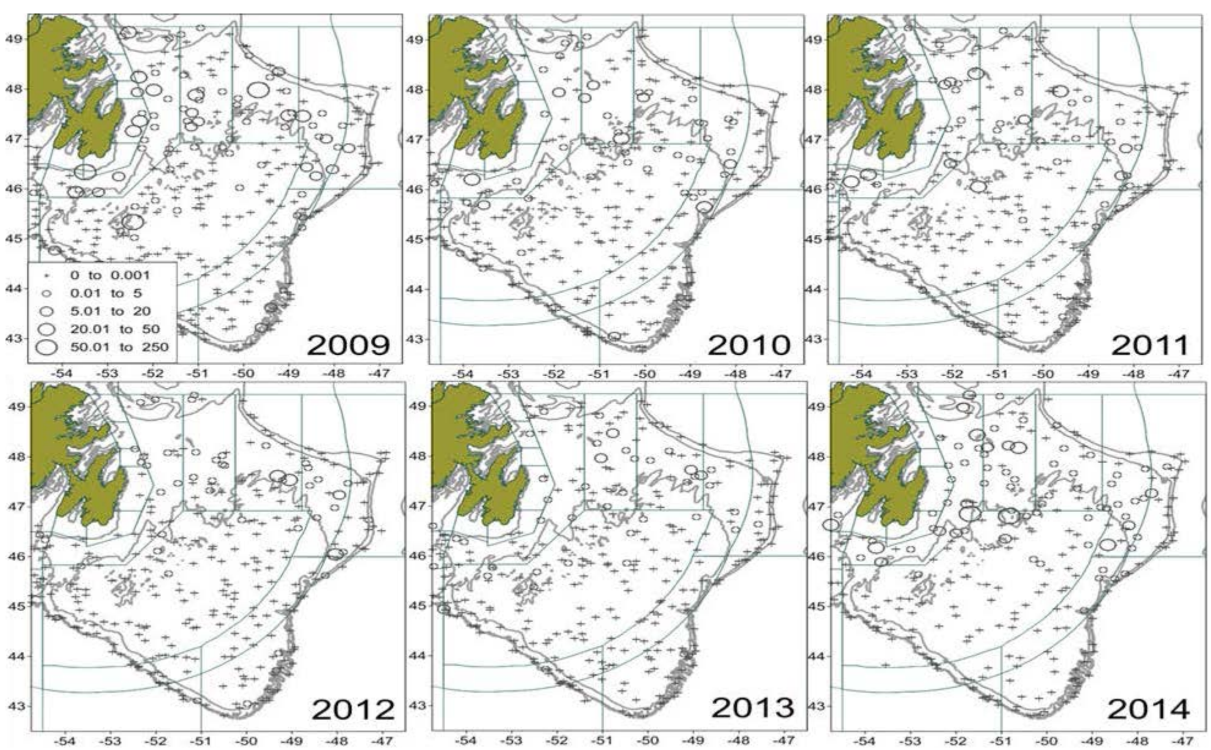


Figure 109: Spatial distribution of catches (#/tow) of mature females from Divs. 3LNO fall offshore trawl surveys from 2009-14.

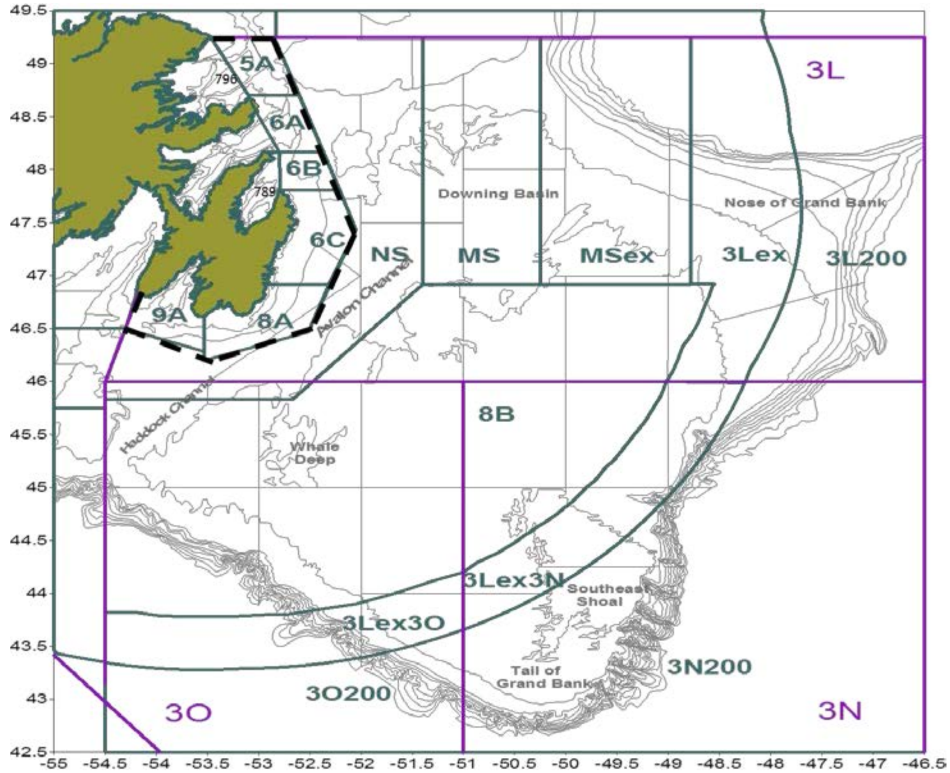


Figure 110: Map of Divs. 3LNO showing CMAs and important bathymetric features. Dashed perimeter indicates Div. 3L inshore areas.

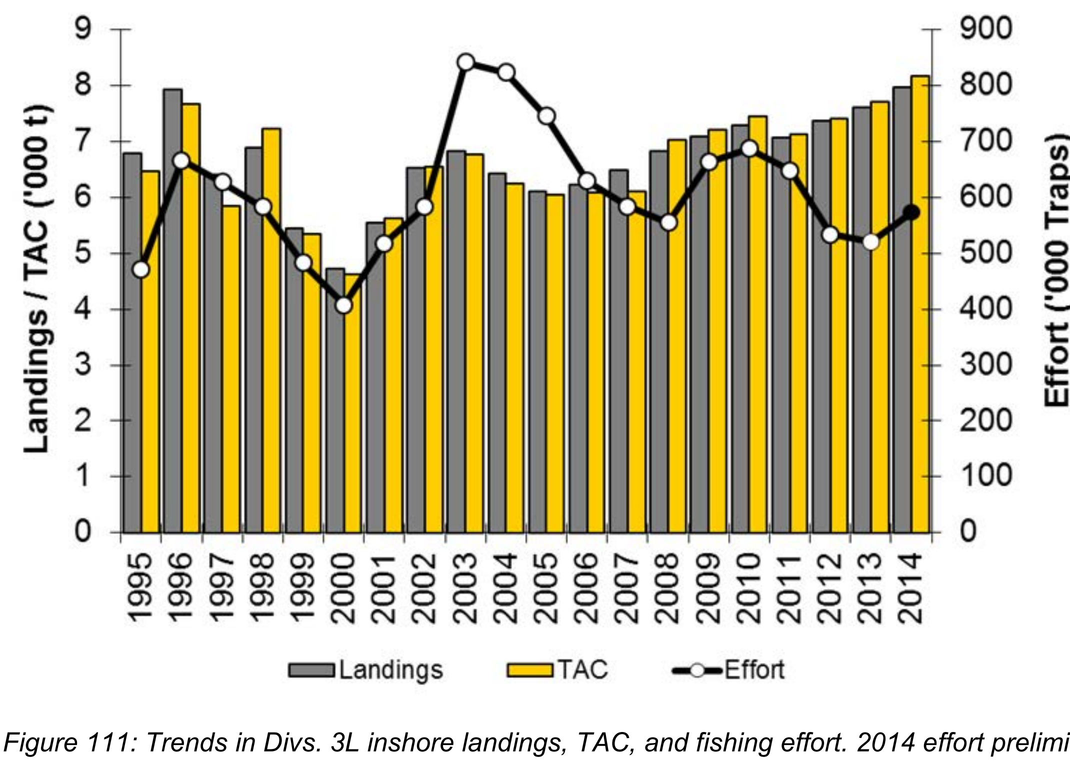


Figure 111: Trends in Divs. 3L inshore landings, TAC, and fishing effort. 2014 effort preliminary.

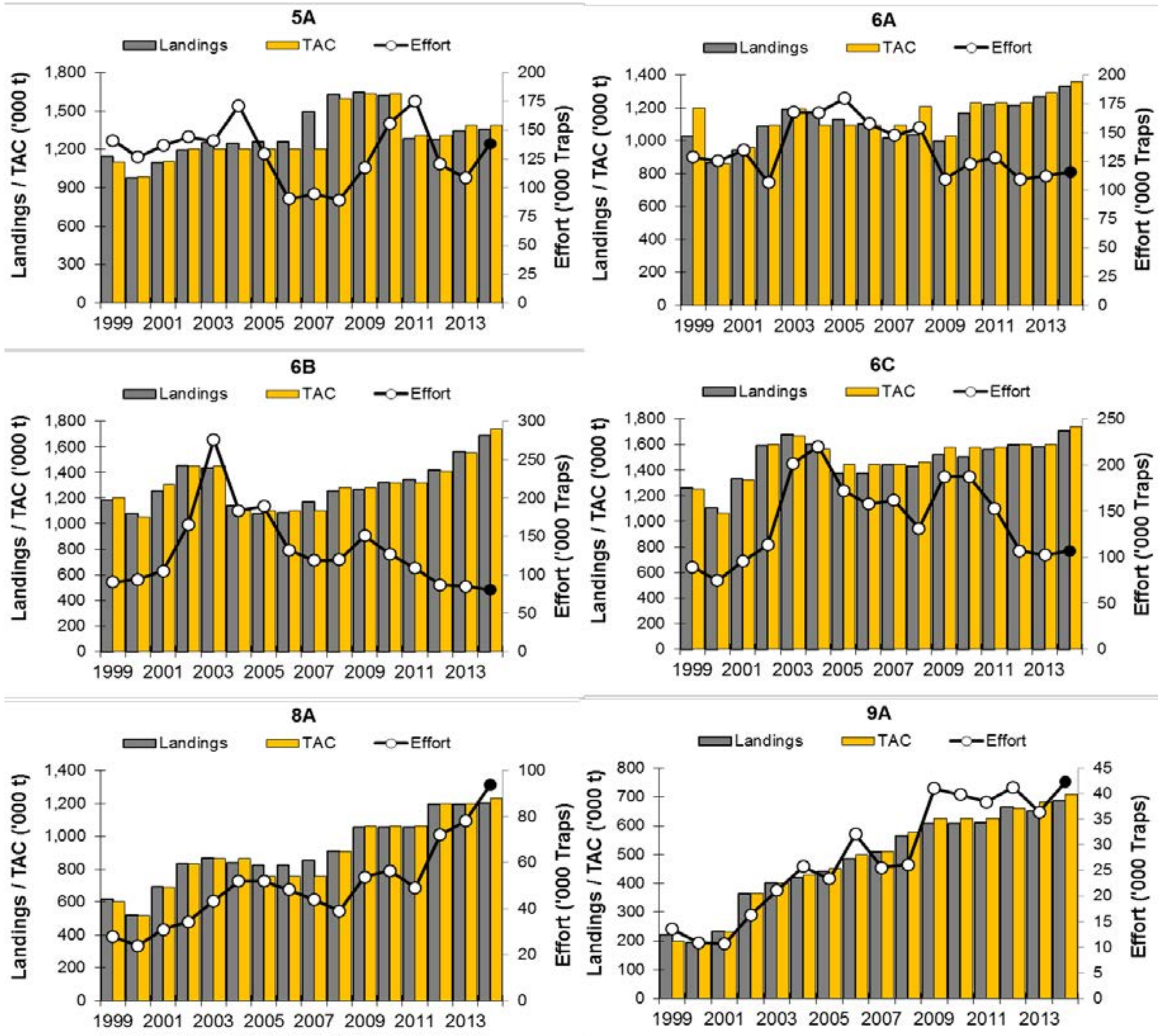


Figure 112: Trends in Div. 3L inshore landings, TAC, and fishing effort by CMA. 2014 effort preliminary.

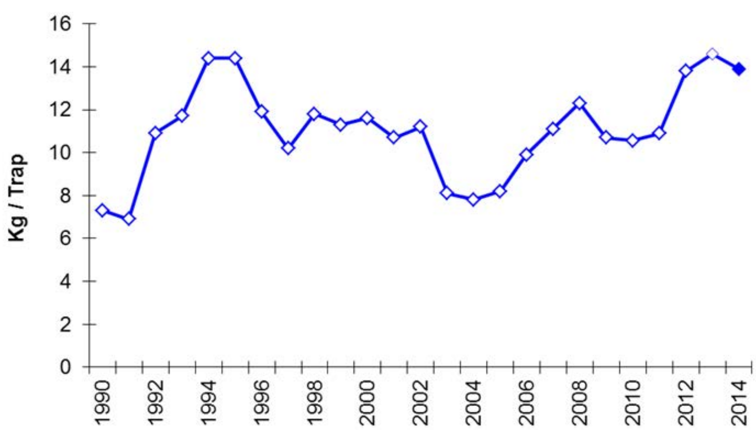


Figure 113: Trends in commercial logbook-based CPUE in the Div. 3L inshore fishery. 2014 estimate preliminary.

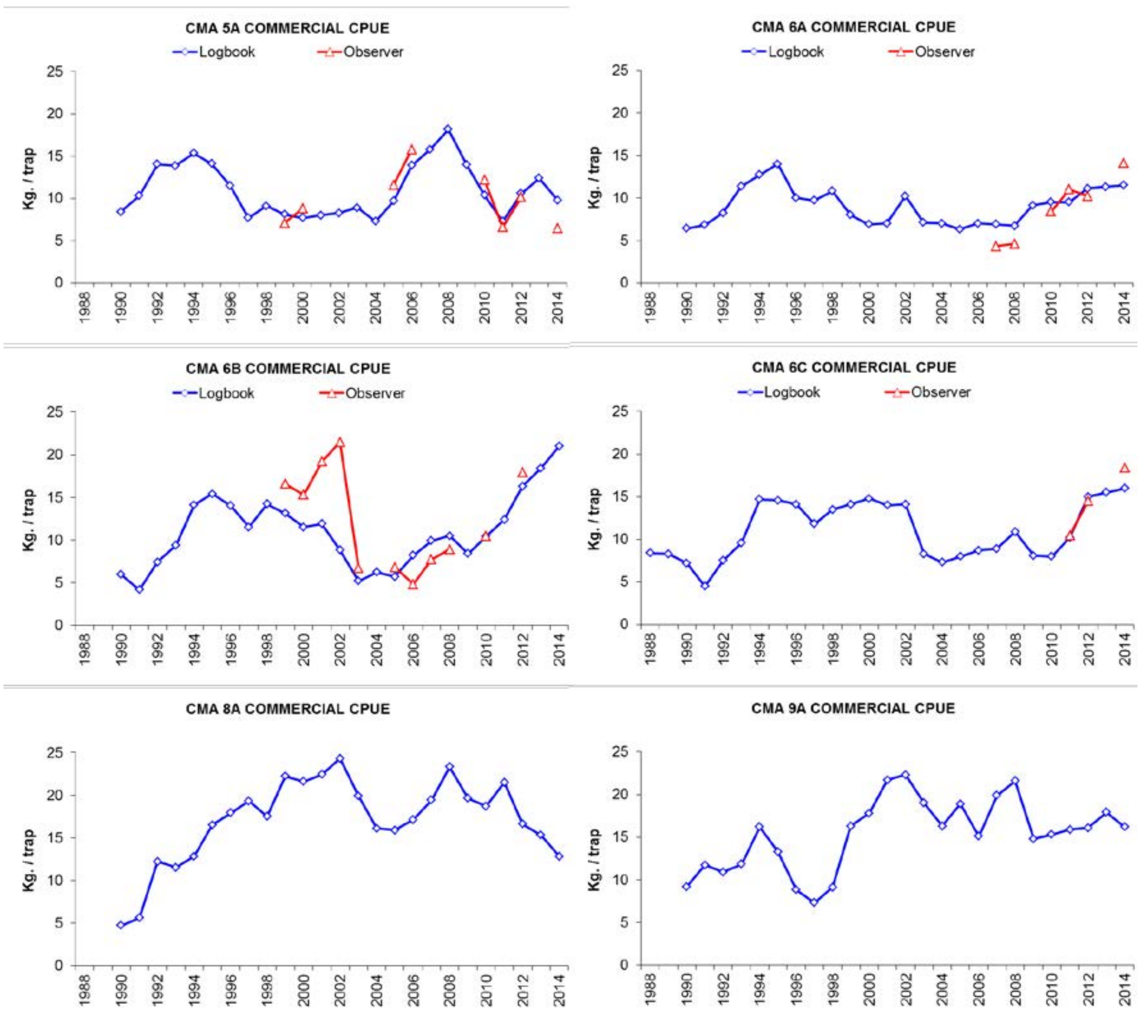


Figure 114: Trends in Div. 3L inshore logbook CPUE and observer CPUE by CMA. 2014 logbook CPUE preliminary.

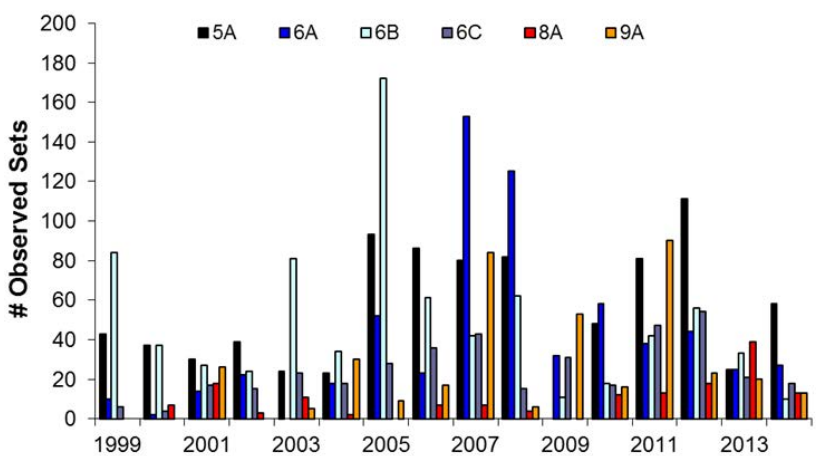


Figure 115: Trends in number of observed sets by CMA and year in Div. 3L inshore.

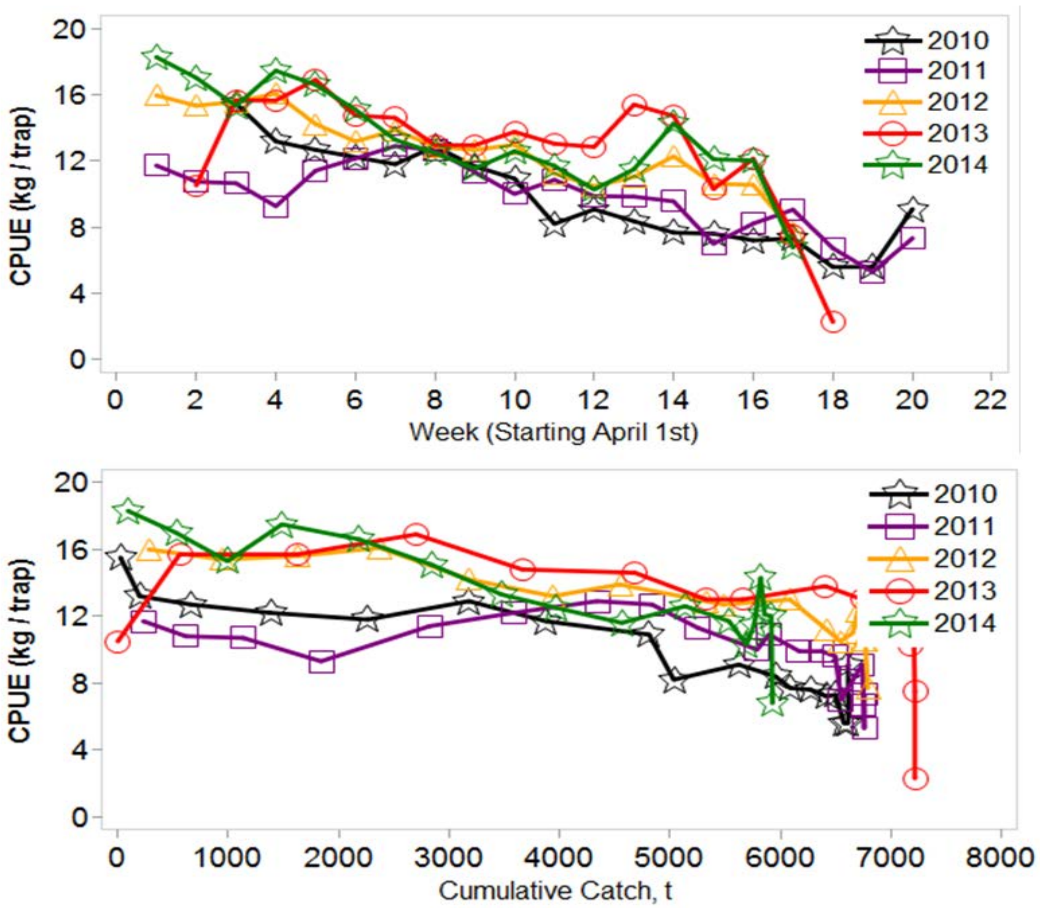


Figure 116: Seasonal trends in VMS-based CPUE for Div. 3L inshore; by week, (above) and in relation to cumulative catch (below).

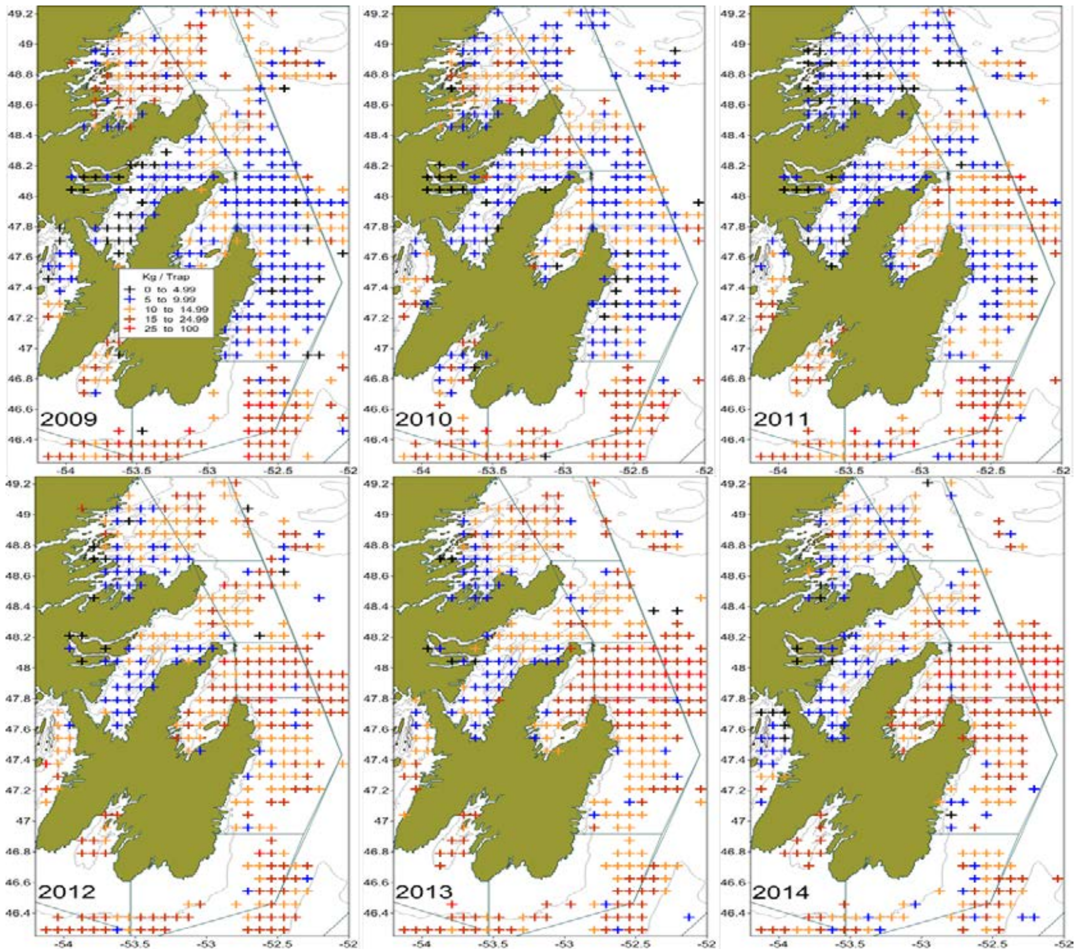


Figure 117: Spatial distribution of Div. 3L inshore logbook CPUE by year.

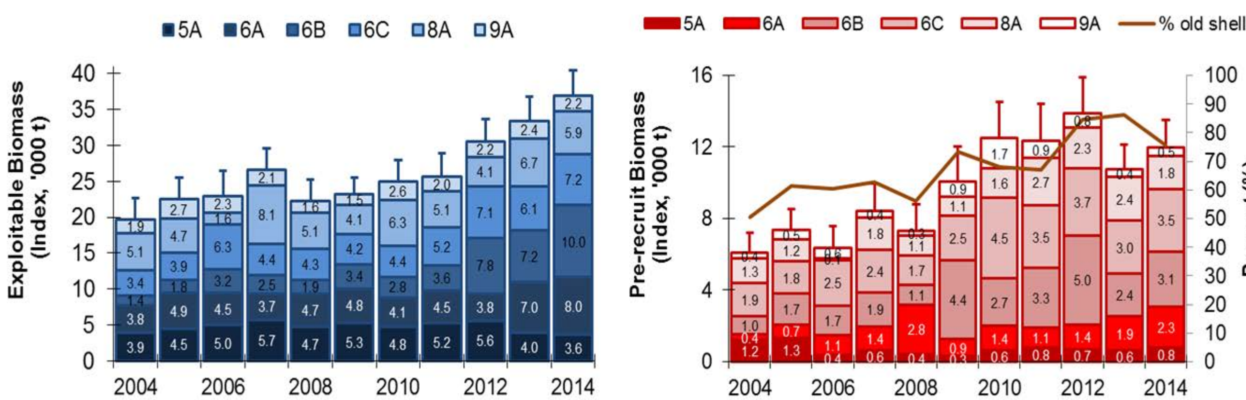


Figure 118: Div. 3L inshore exploitable (left) and pre-recruit (right) biomass indices by CMA (left) from the CPS trap survey. The brown line on the pre-recruit plot represents the percentage of sub-legal-sized crabs that were old-shelled.

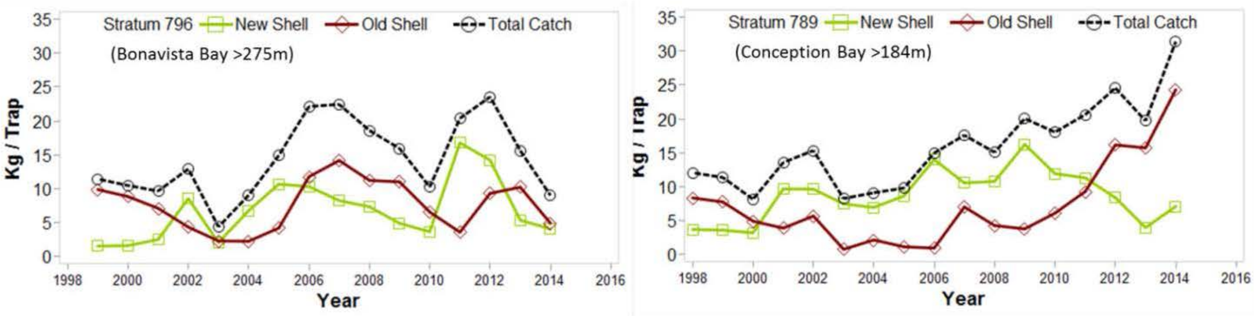


Figure 119: Trends in CPUE by shell condition for legal-sized crabs from strata occupied in the DFO trap survey in Div. 3L inshore.

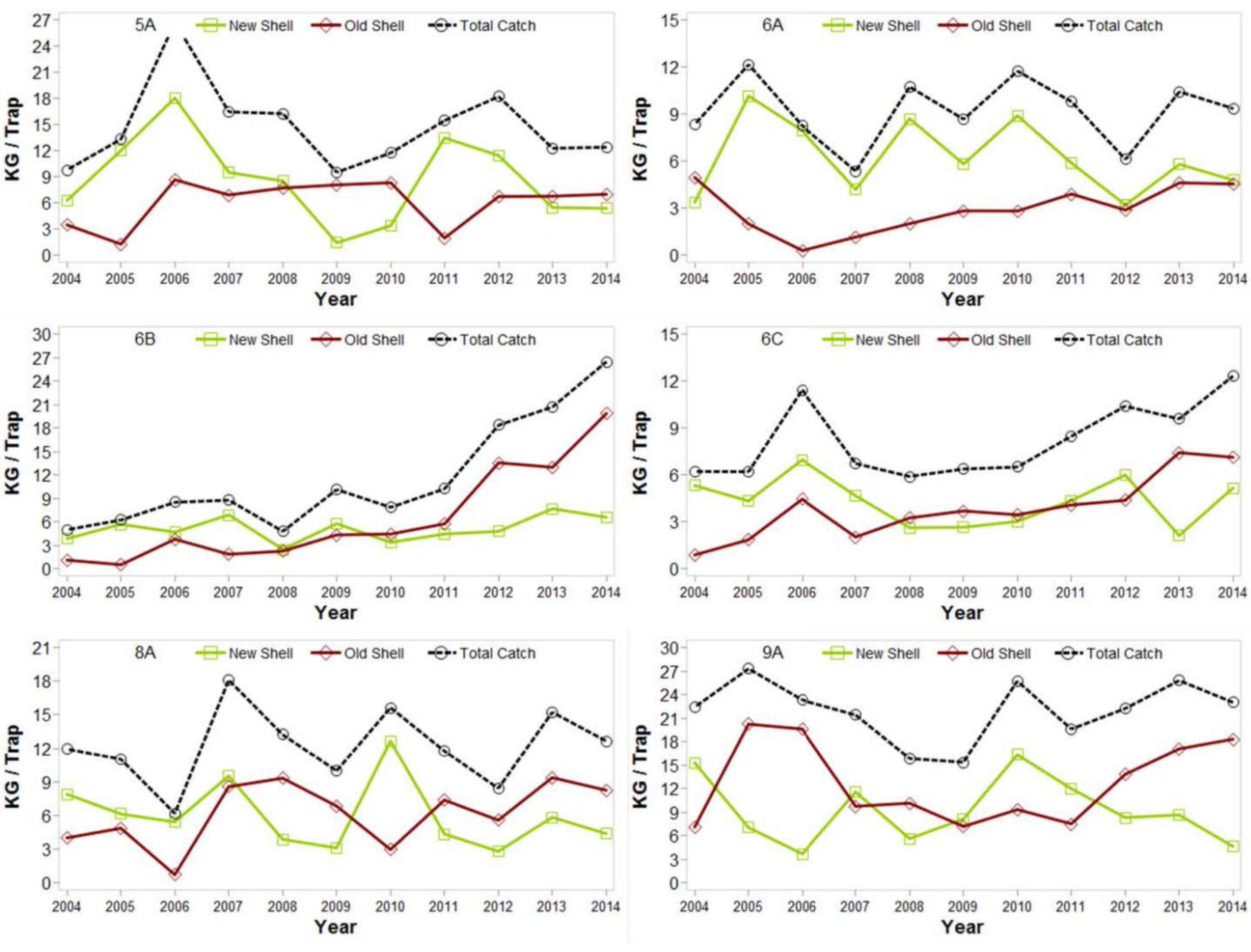


Figure 120: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in Div. 3L inshore CMAs.

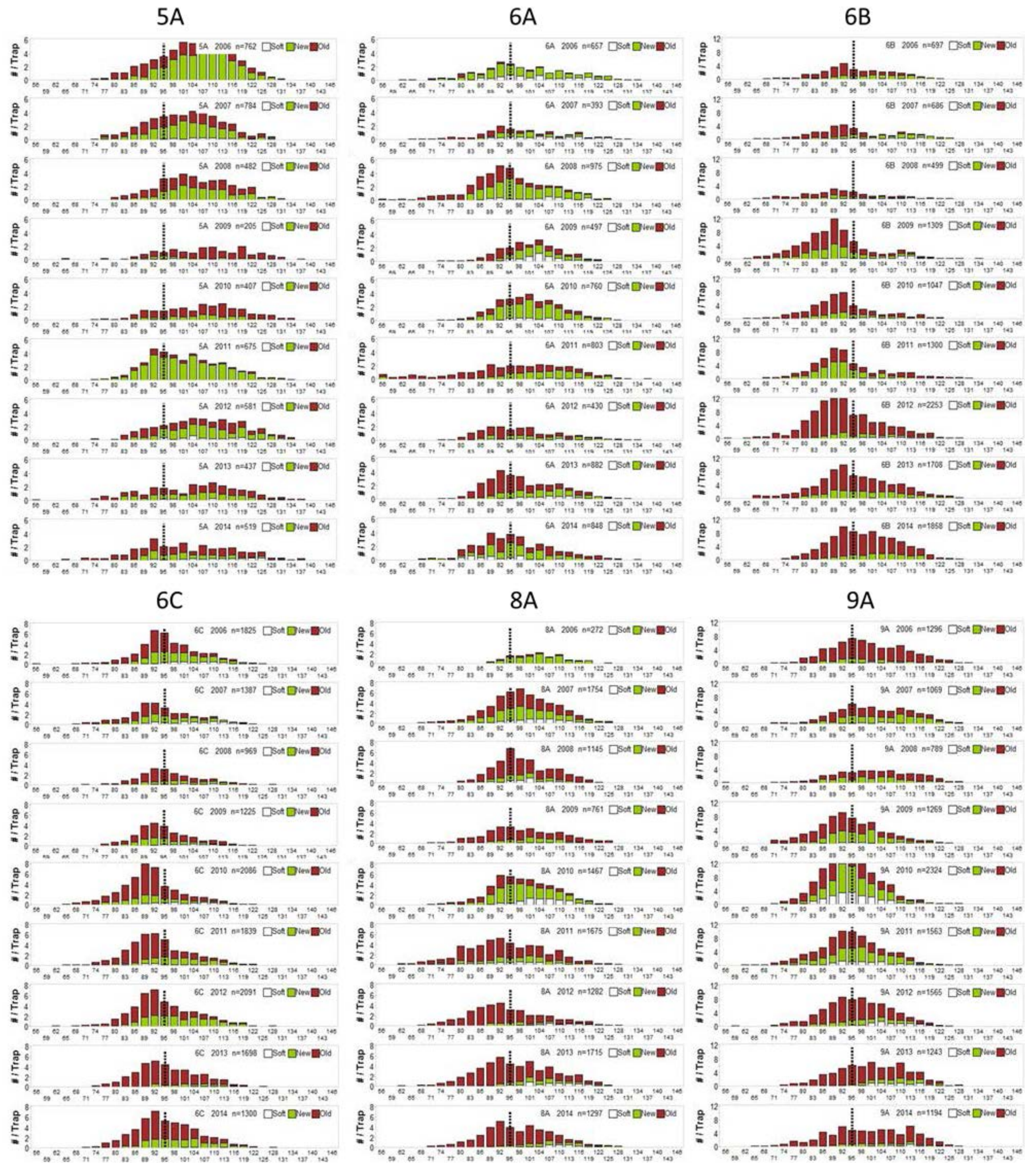


Figure 121: Trends in male carapace width distributions from core stations in the Div. 3L inshore CPS trap survey by CMA. The vertical dashed line indicates the minimum legal size.

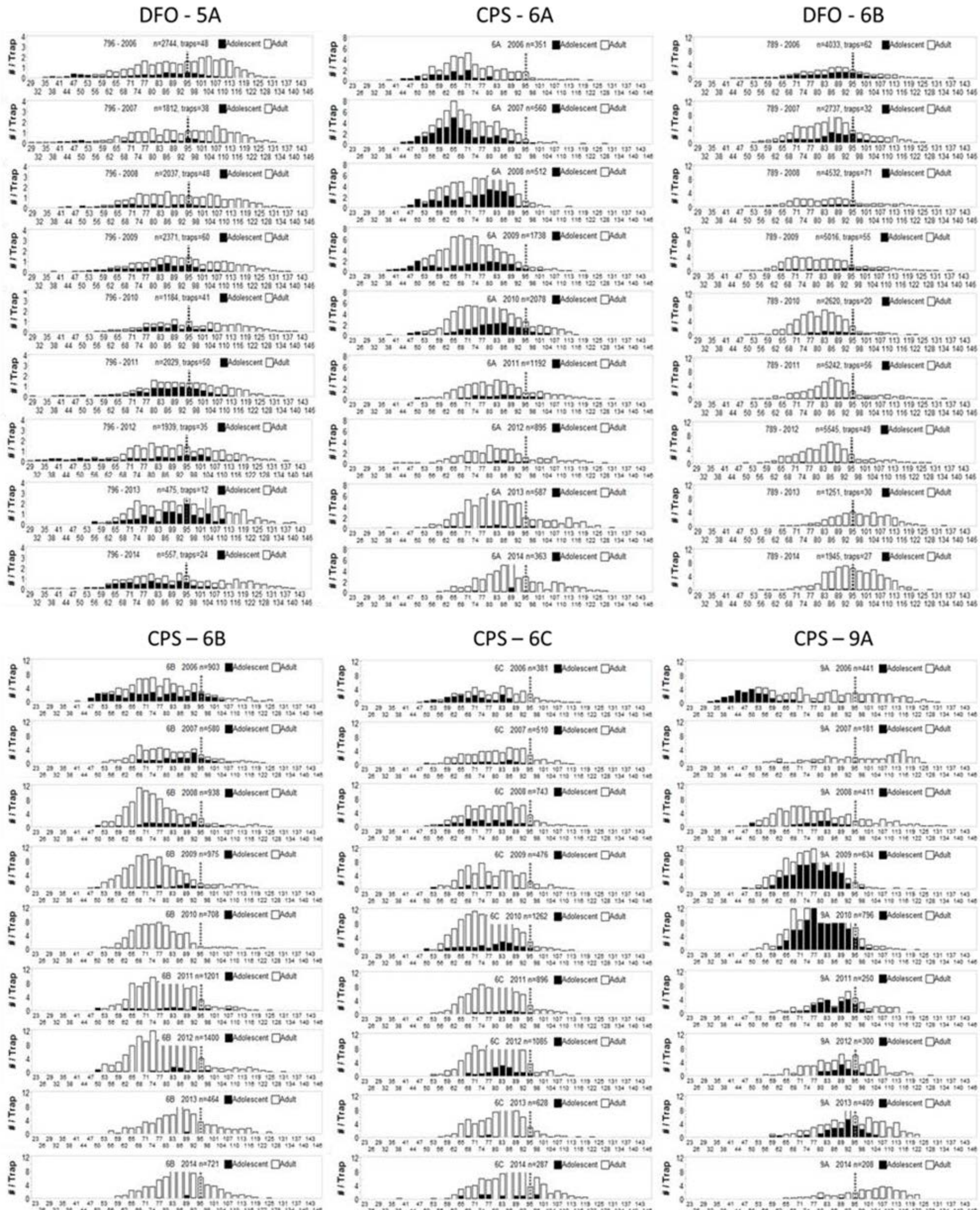


Figure 122: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in DFO and CPS trap surveys in Green Bay (CMA 3C) and Notre Dame Bay (CMA 3D). The vertical dashed line indicates the minimum legal size.

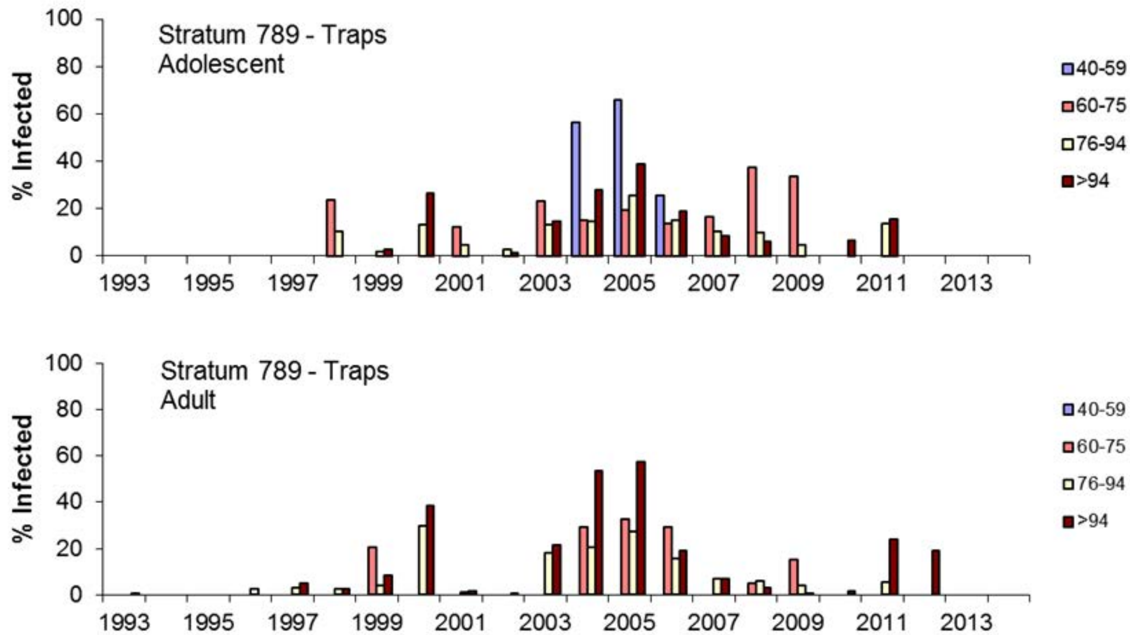


Figure 123: Trends in prevalence of BCD in new-shelled males by year and size group in stratum 789 from DFO trap surveys in Conception Bay; adolescents (above) and adults (below).

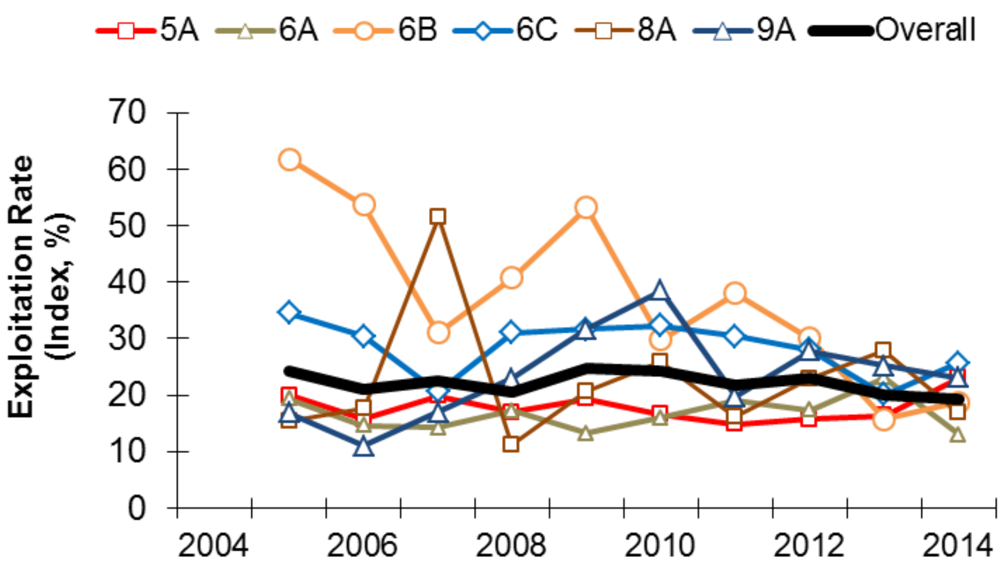


Figure 124: Exploitation rate indices by CMA as well as overall for Div. 3L inshore based on the CPS trap survey.

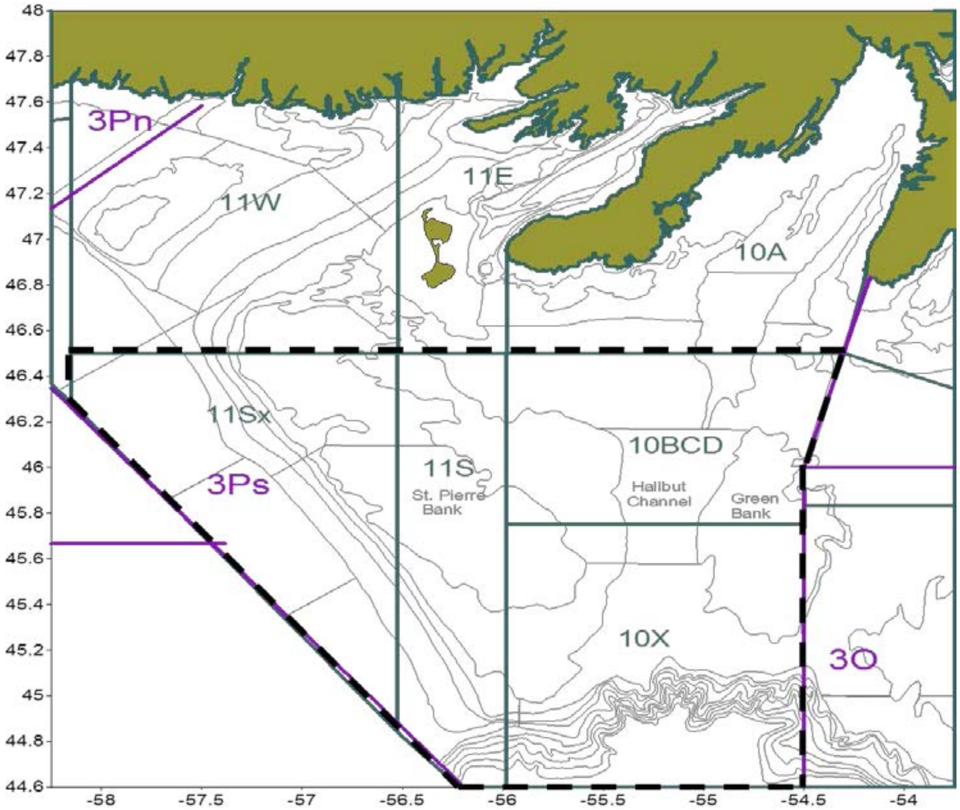


Figure 125: Map of Subdiv. 3Ps showing CMAs and important bathymetric features. Dashed perimeter indicates offshore areas.

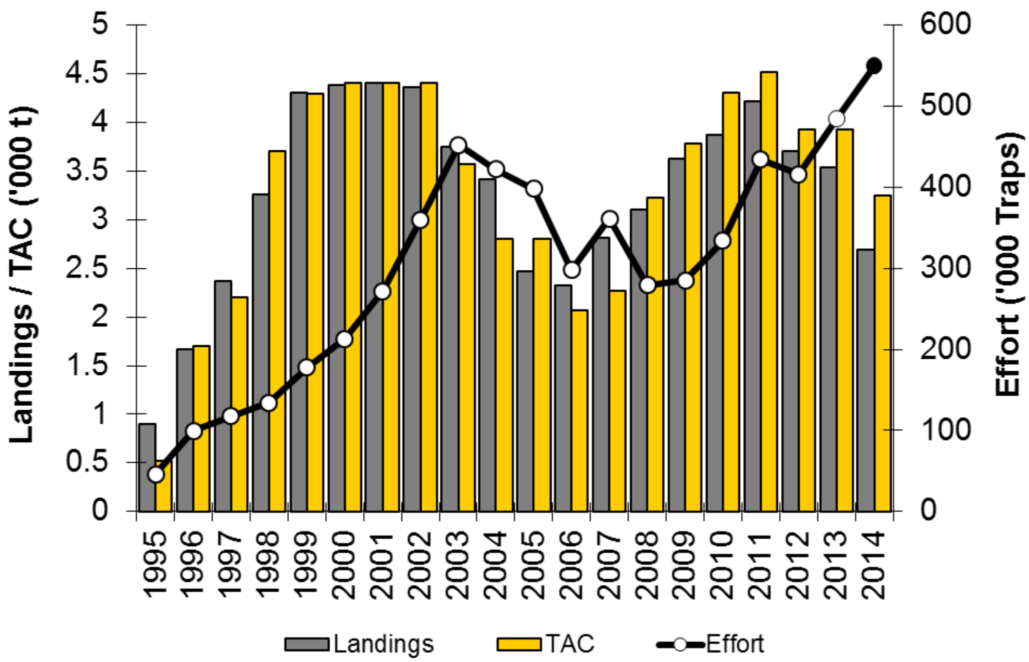


Figure 126: Trends in Subdiv. 3Ps offshore landings, TAC, and fishing effort. 2014 effort preliminary.

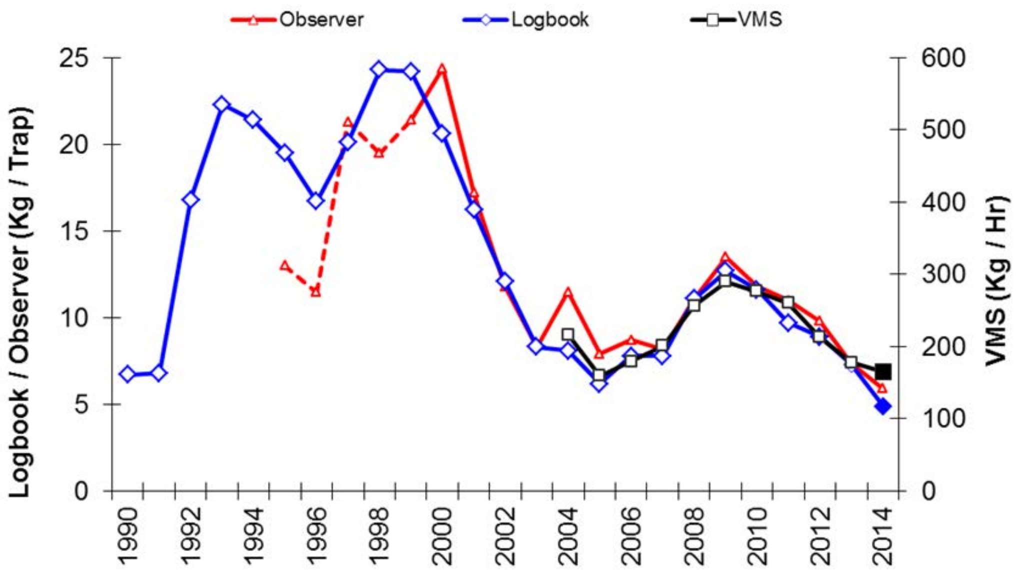


Figure 127: Trends in commercial logbook-based, observer-based, and VMS-based CPUE in the Subdiv. 3Ps offshore fishery. 2014 logbook and VMS CPUE estimates preliminary.

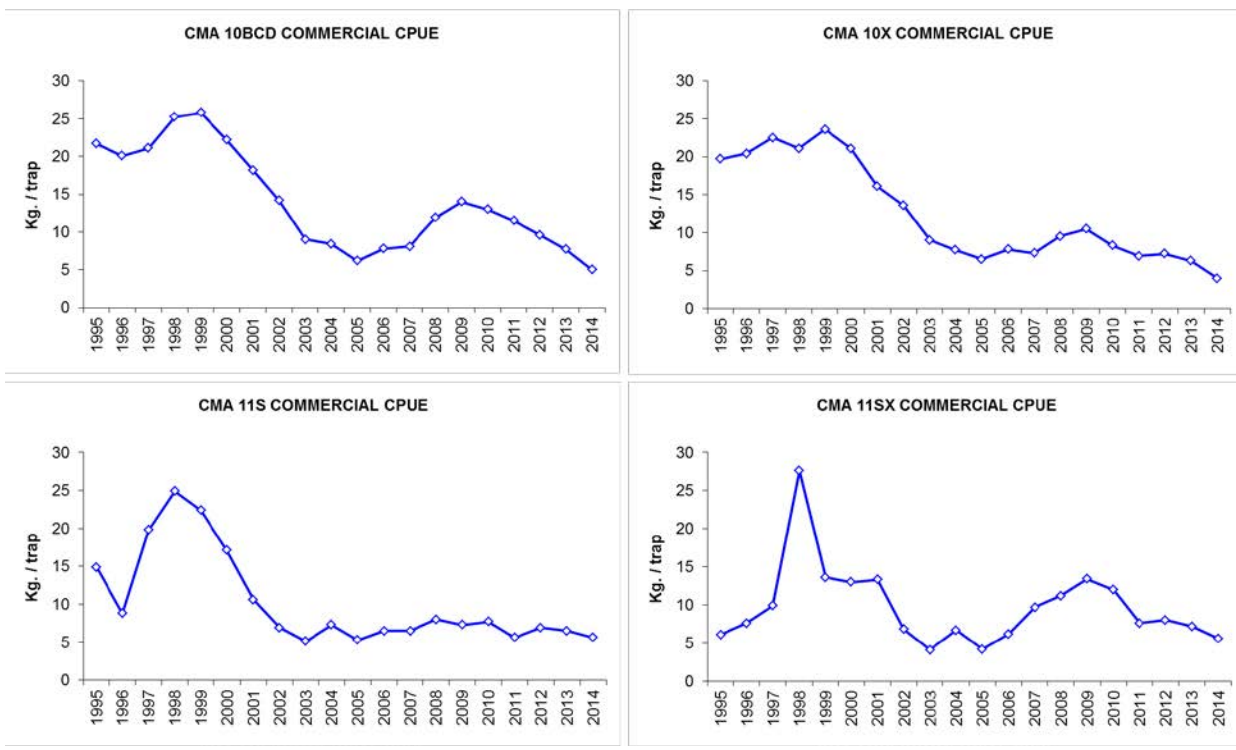


Figure 128: Trends in Subdiv. 3Ps offshore logbook CPUE by CMA. 2014 logbook CPUE preliminary.

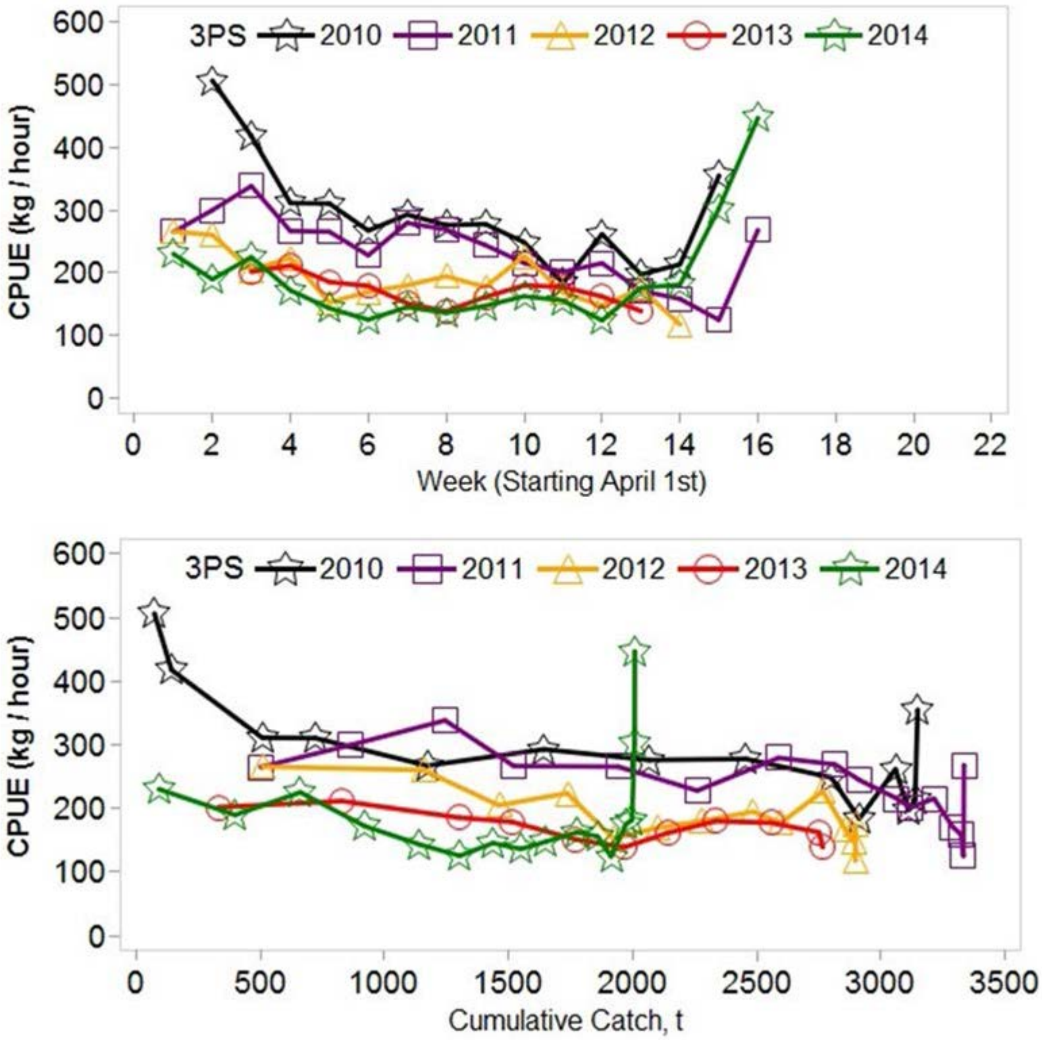


Figure 129: Seasonal trends in VMS-based CPUE for Subdiv. 3Ps offshore; by week (above), and in relation to cumulative catch (below).

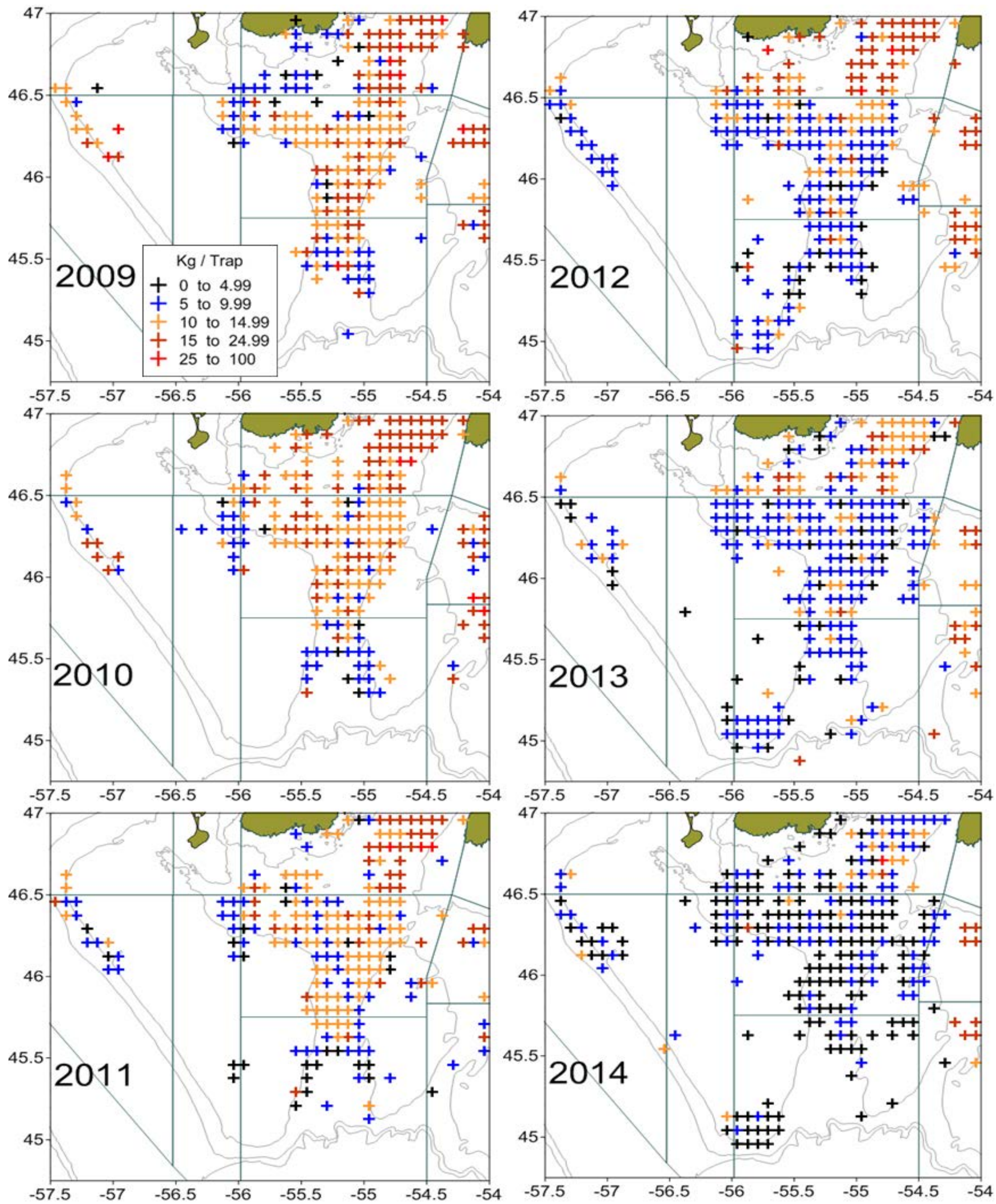


Figure 130: Spatial distribution of Subdiv. 3Ps offshore logbook CPUE by year.

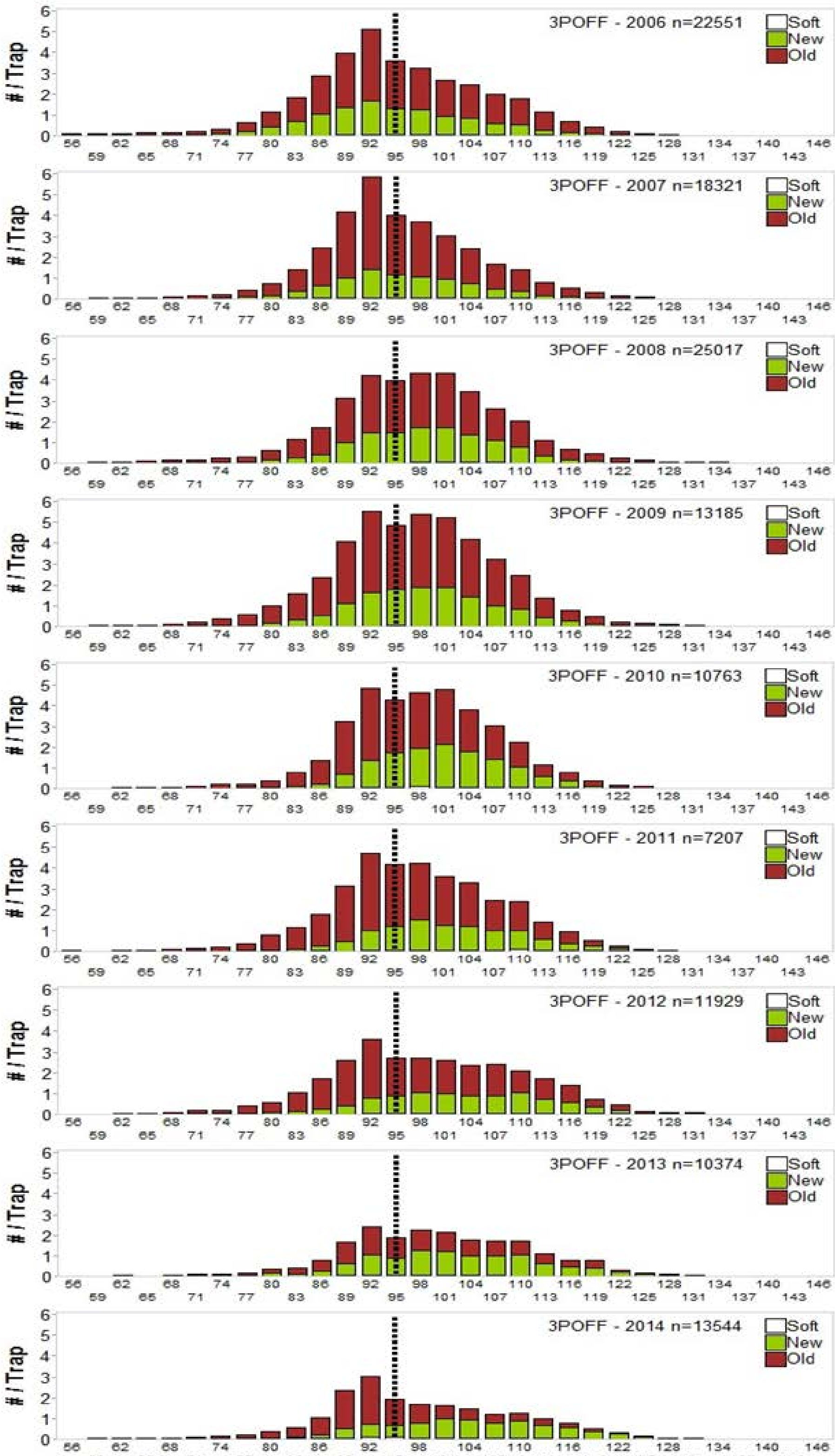


Figure 131: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Subdiv. 3Ps offshore. The vertical dashed line indicates the minimum legal size.

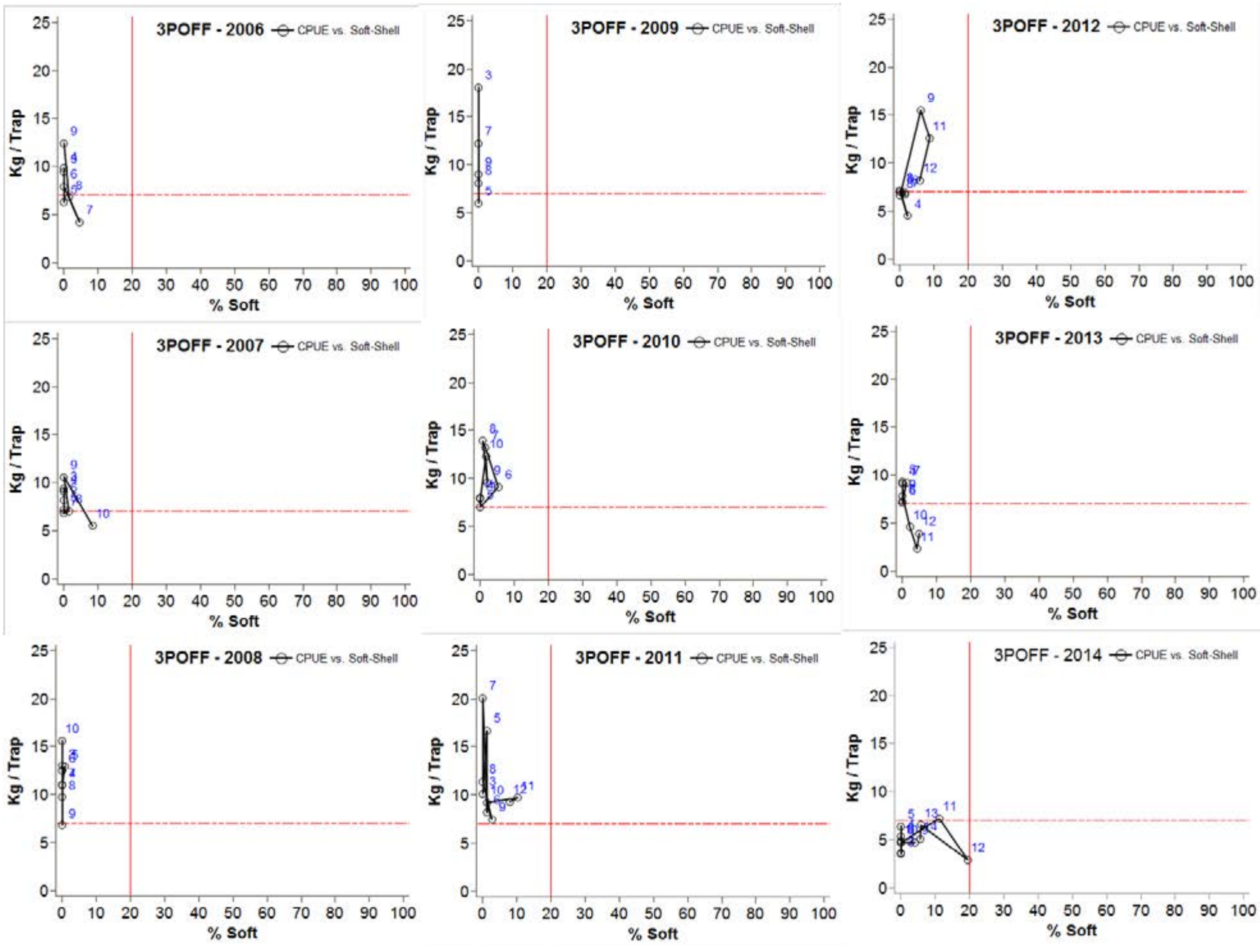


Figure 132: Trends in weekly percentages of kept vs. soft-shell crab in Subdiv. 3Ps offshore from at-sea sampling by observers.

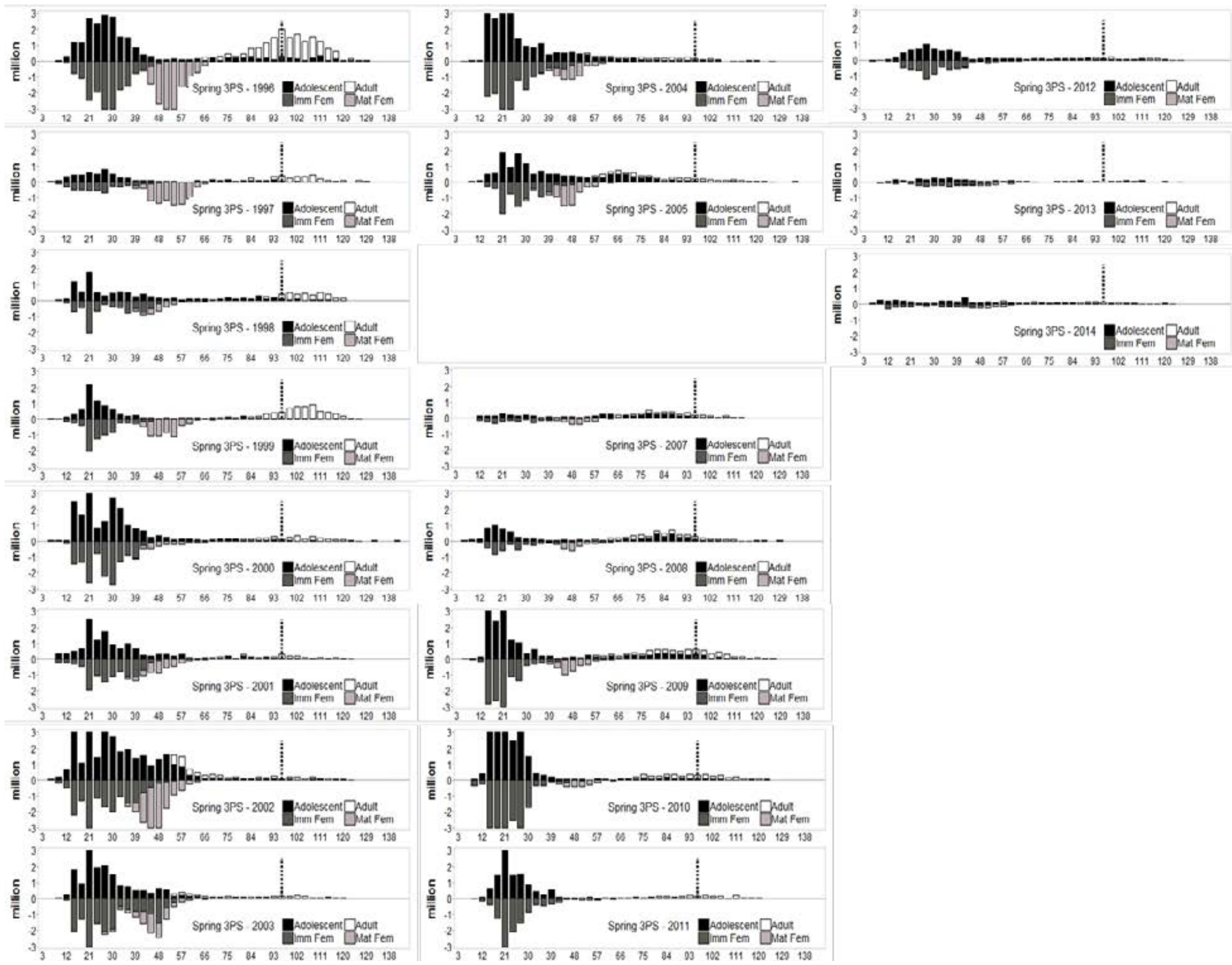


Figure 133: Abundance indices by carapace width for Subdiv. 3Ps offshore juveniles plus adolescent males (dark bars), adult males (white bars), immature females (dark grey bars) and mature females (light grey bars) from spring trawl surveys.

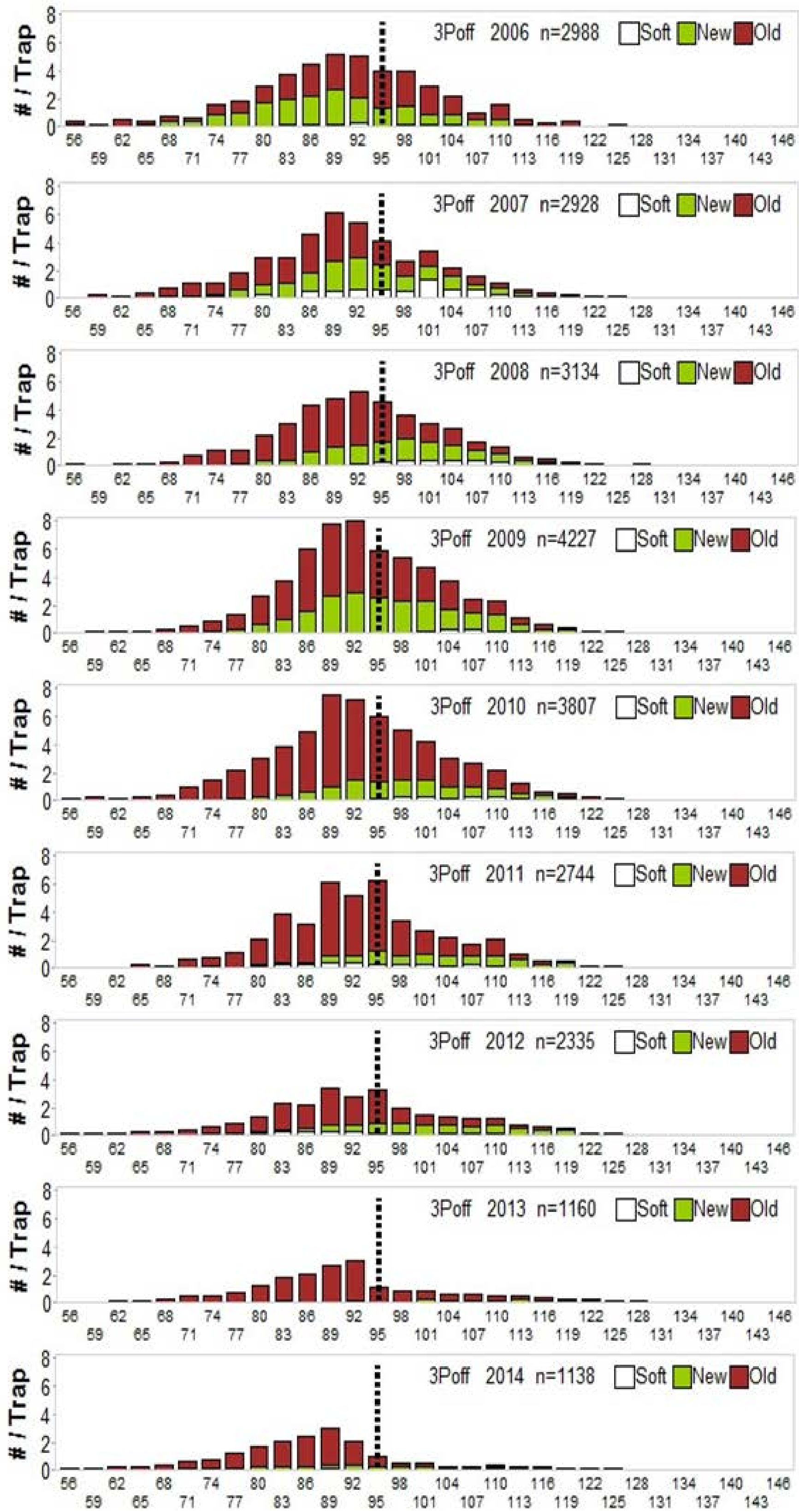


Figure 134: Trends in male carapace width distributions from large mesh traps at core stations in the Subdiv. 3Ps offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

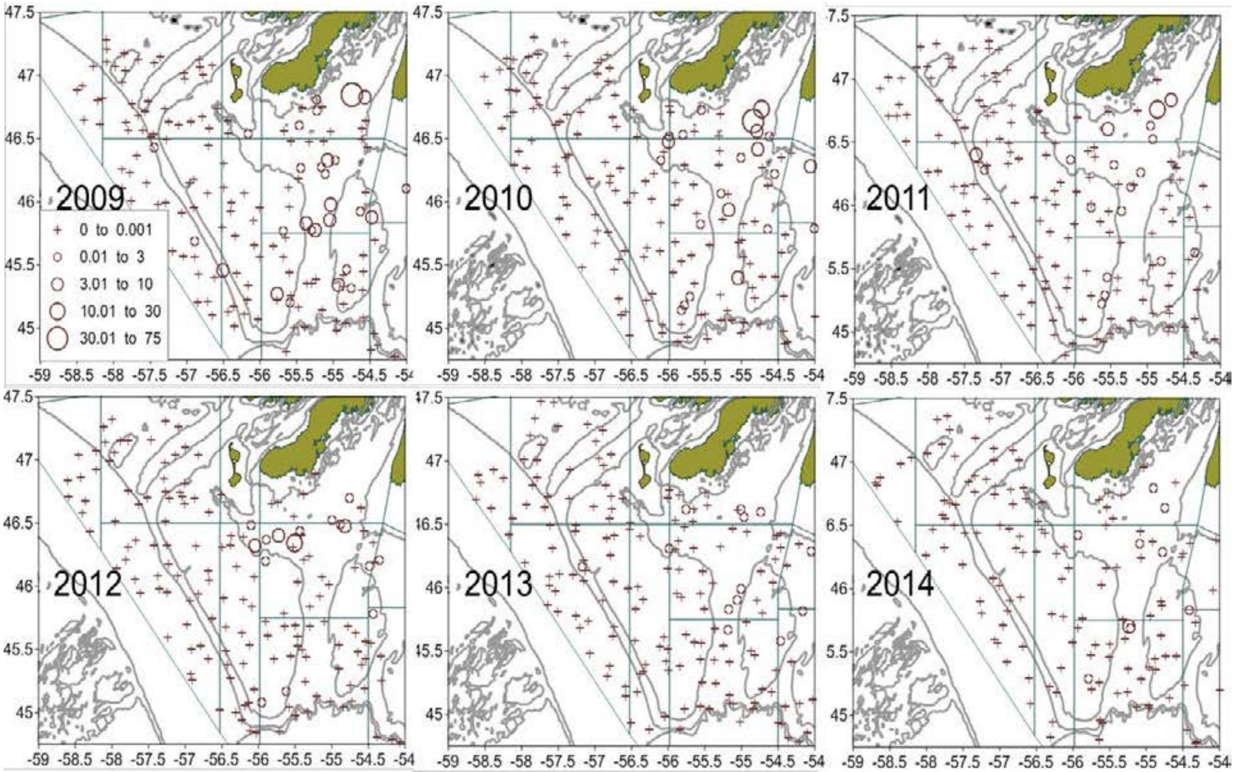


Figure 135: Spatial distribution of catches (#/tow) of exploitable males (> 94 mm CW adults) from Subdiv. 3Ps spring offshore trawl surveys from 2009-14.

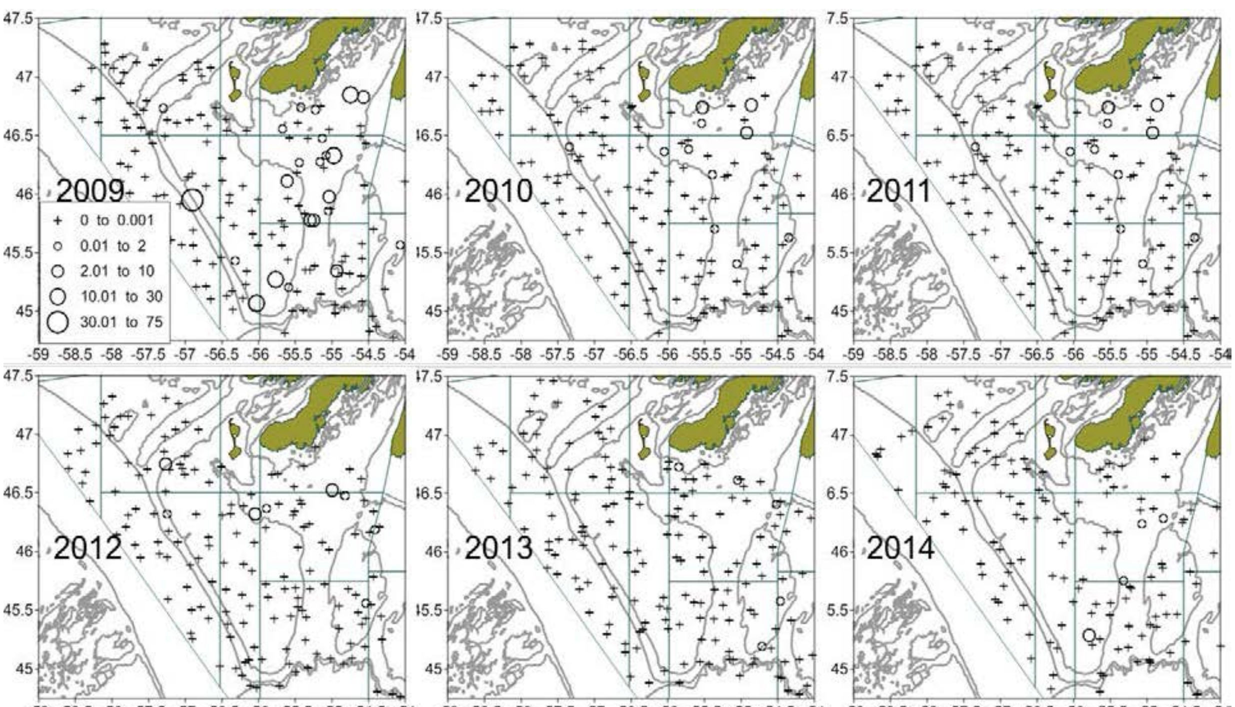


Figure 136: Spatial distribution of catches (#/tow) of pre-recruit males (> 76 mm CW adolescents) from Subdiv. 3Ps spring offshore trawl surveys from 2009-14.

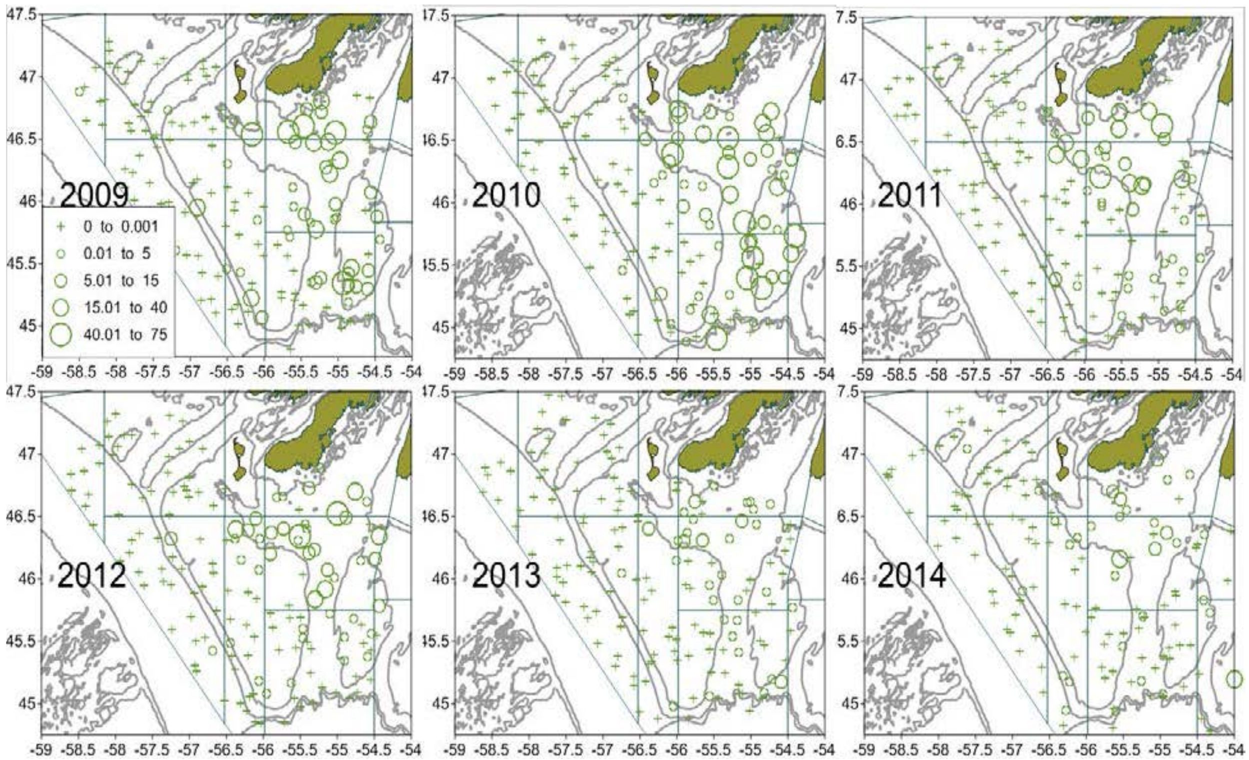


Figure 137: Spatial distribution of catches (#/tow) of small males (> 60 mm CW adolescents) from Subdiv. 3Ps spring offshore trawl surveys from 2009-14.

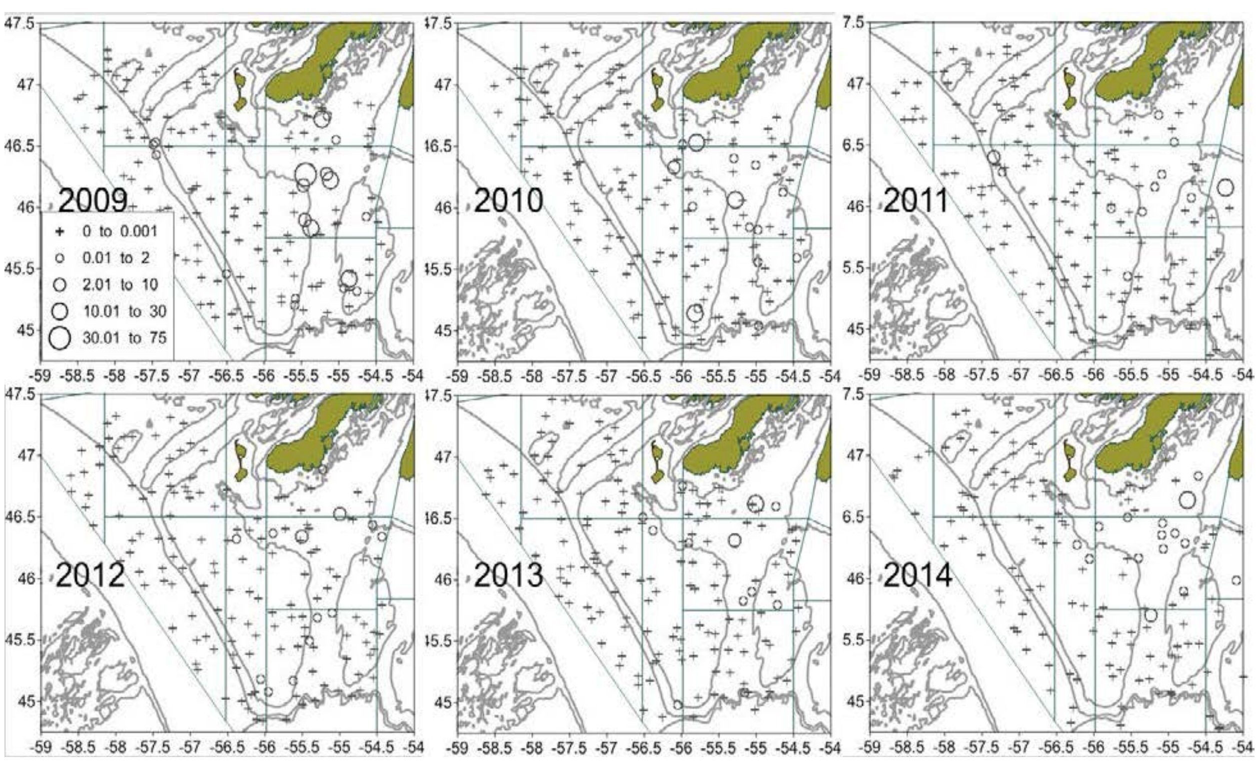


Figure 138: Spatial distribution of catches (#/tow) of pre-recruit males (> 76 mm CW adolescents) from Subdiv. 3Ps spring offshore trawl surveys from 2009-14.

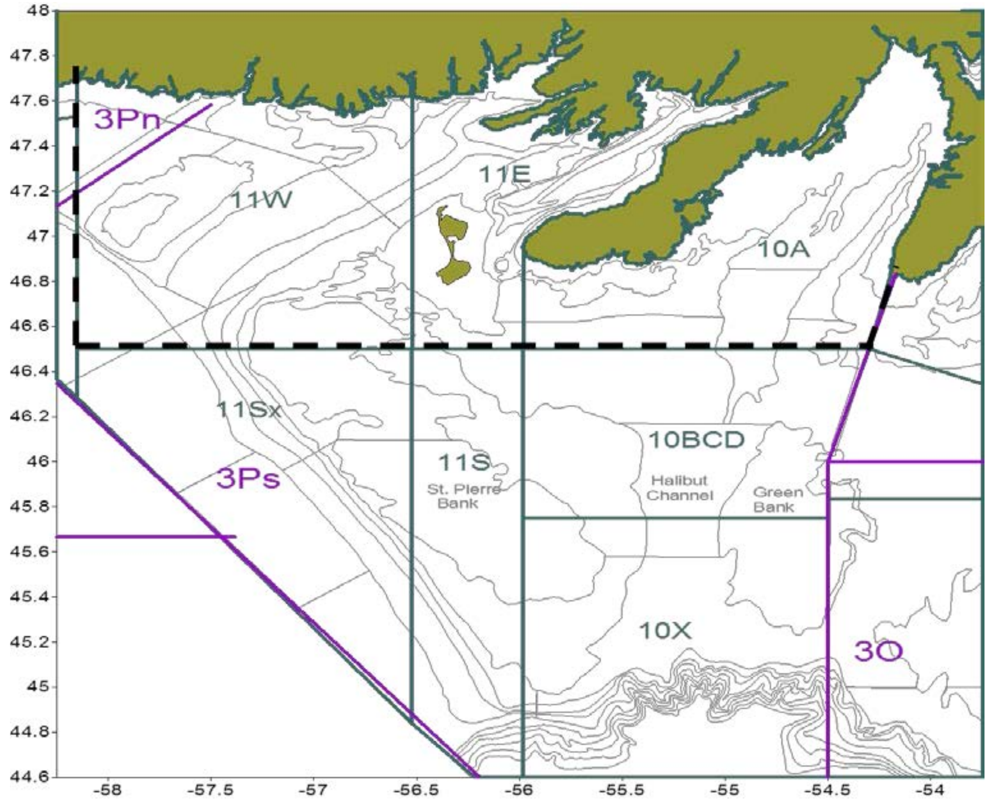


Figure 139: Map of Subdiv. 3Ps showing CMAs and important bathymetric features. Dashed perimeter indicates inshore areas.

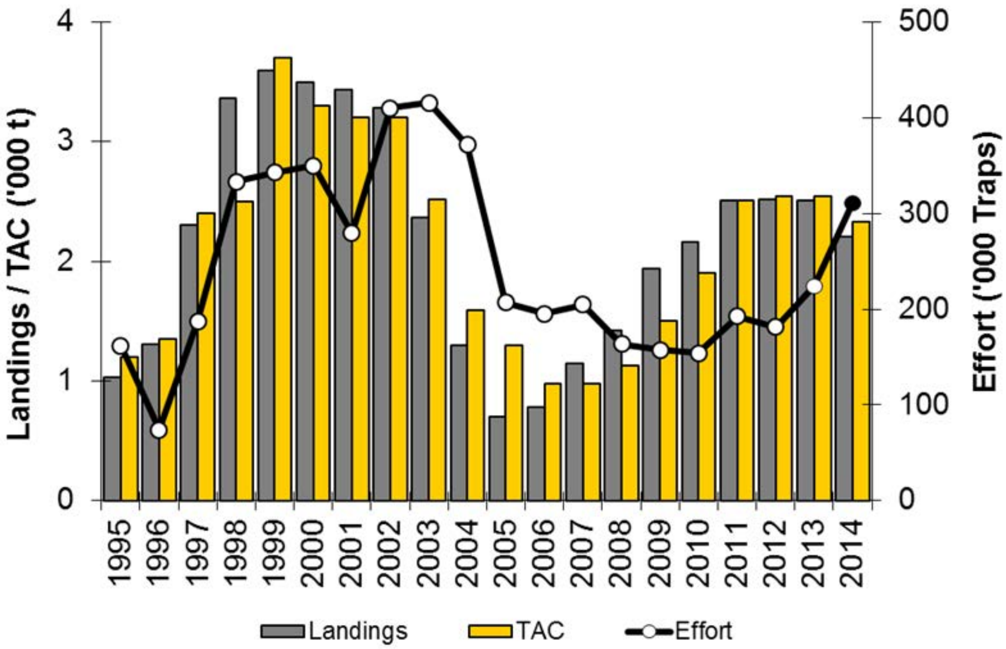


Figure 140: Trends in Subdiv. 3Ps inshore landings, TAC, and fishing effort. 2014 effort preliminary.

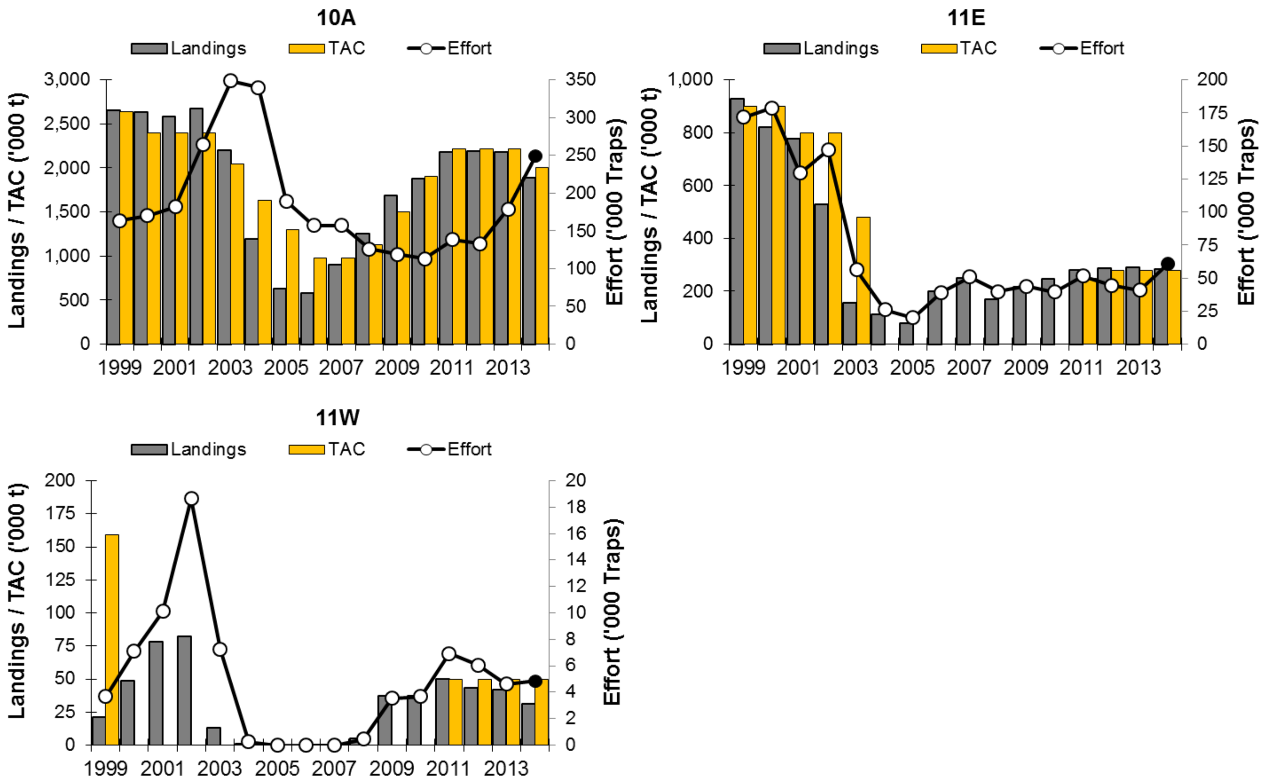


Figure 141: Trends in Subdiv. 3Ps inshore landings, TAC, and fishing effort by CMA. 2014 effort preliminary.

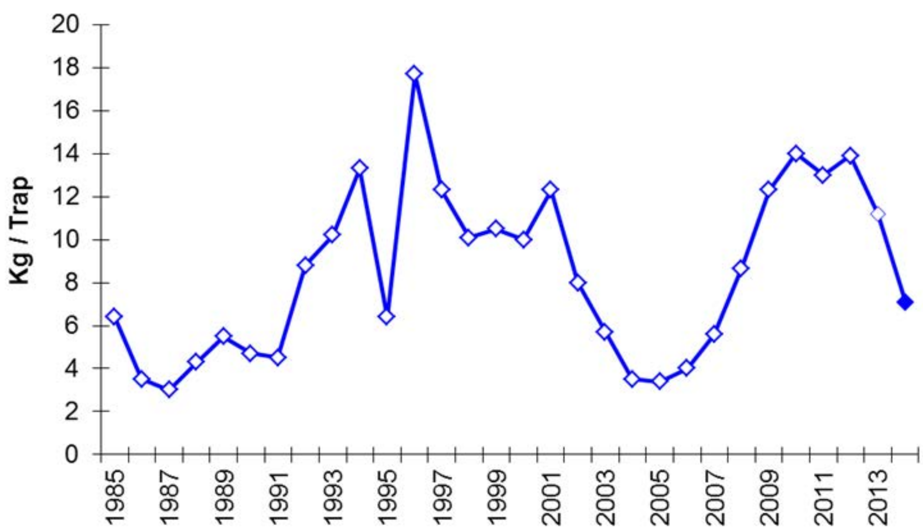


Figure 142: Trends in commercial logbook-based CPUE in the Subdiv. 3Ps inshore fishery. 2014 estimate preliminary.

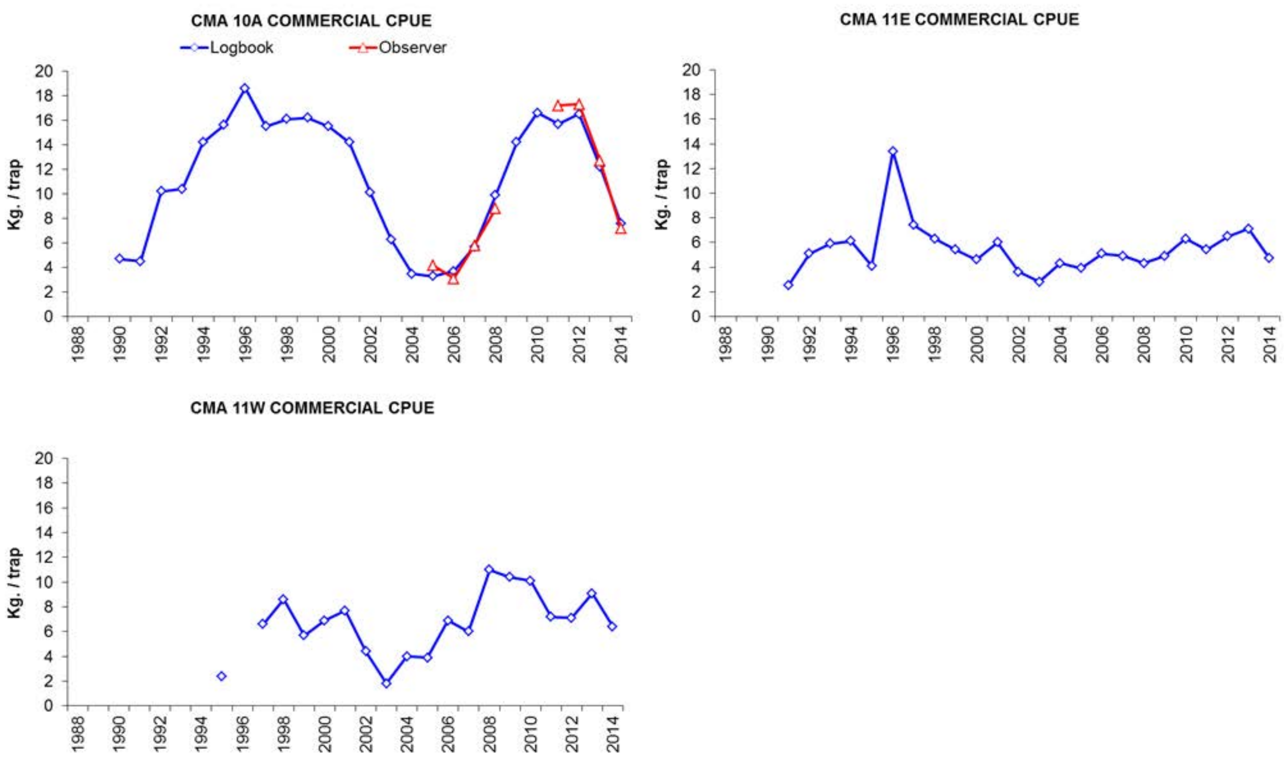


Figure 143: Trends in Subdiv. 3Ps inshore logbook CPUE and observer CPUE by CMA. 2014 logbook CPUE preliminary.

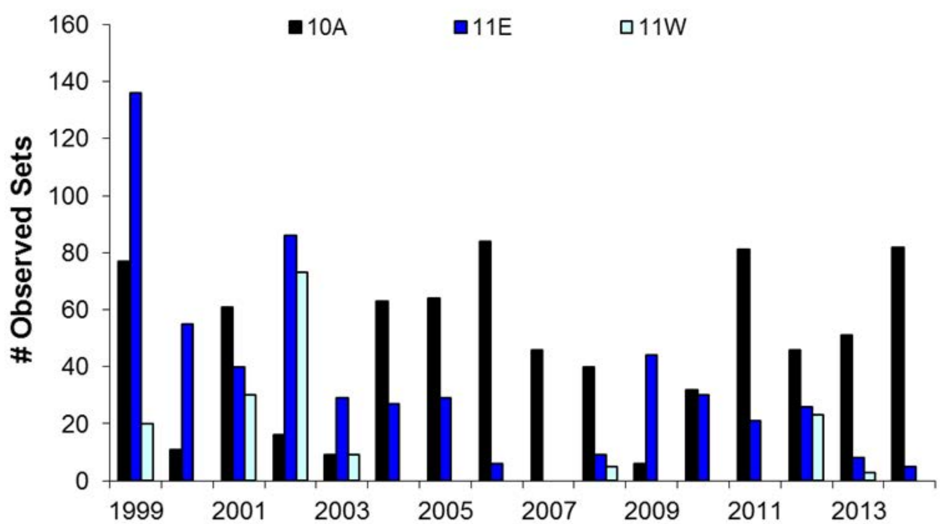
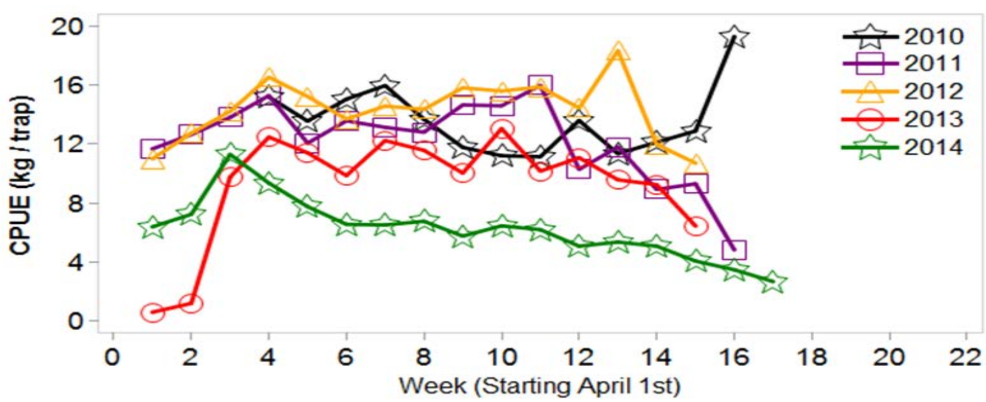


Figure 144: Trends in number of observed sets by CMA and year in Subdiv. 3Ps inshore.



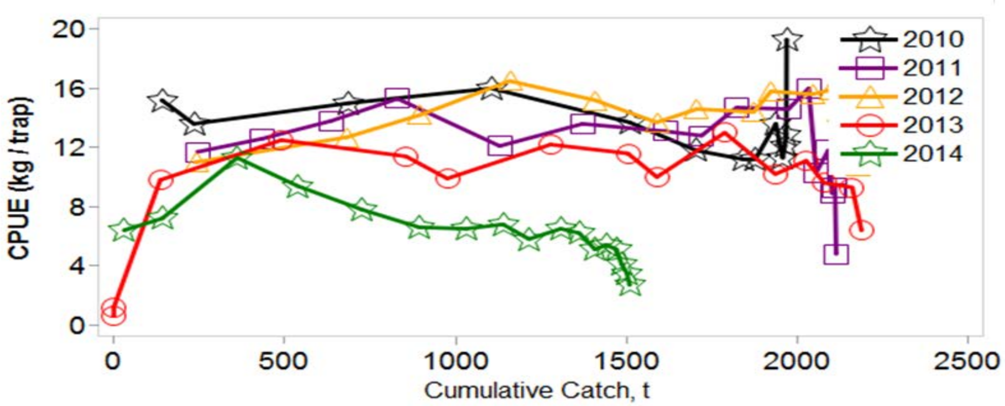


Figure 145: Seasonal trends in logbook-based CPUE for Subdiv. 3Ps inshore; by week (above), and in relation to cumulative catch (below).

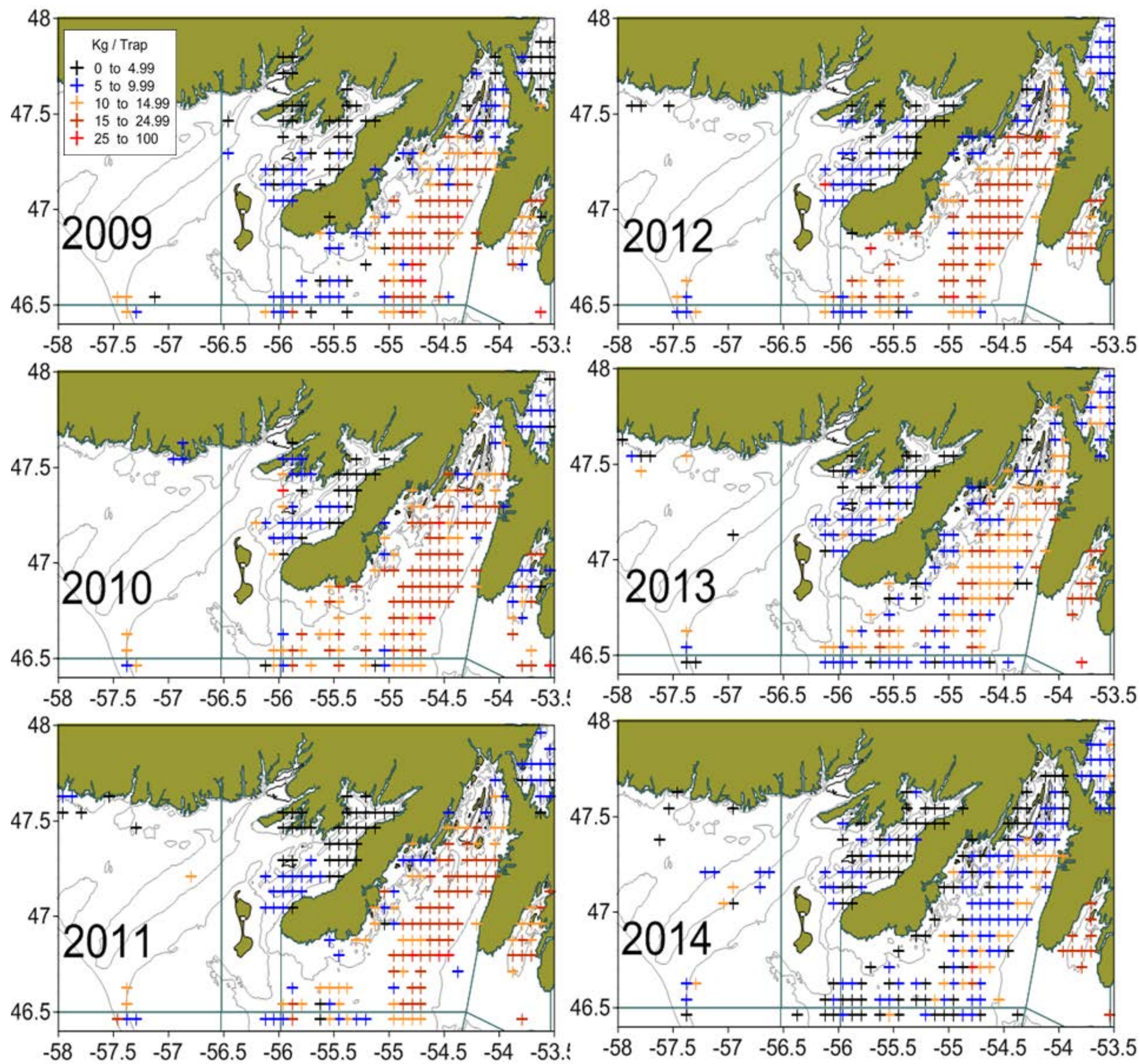


Figure 146: Spatial distribution of Subdiv. 3Ps inshore logbook CPUE by year.

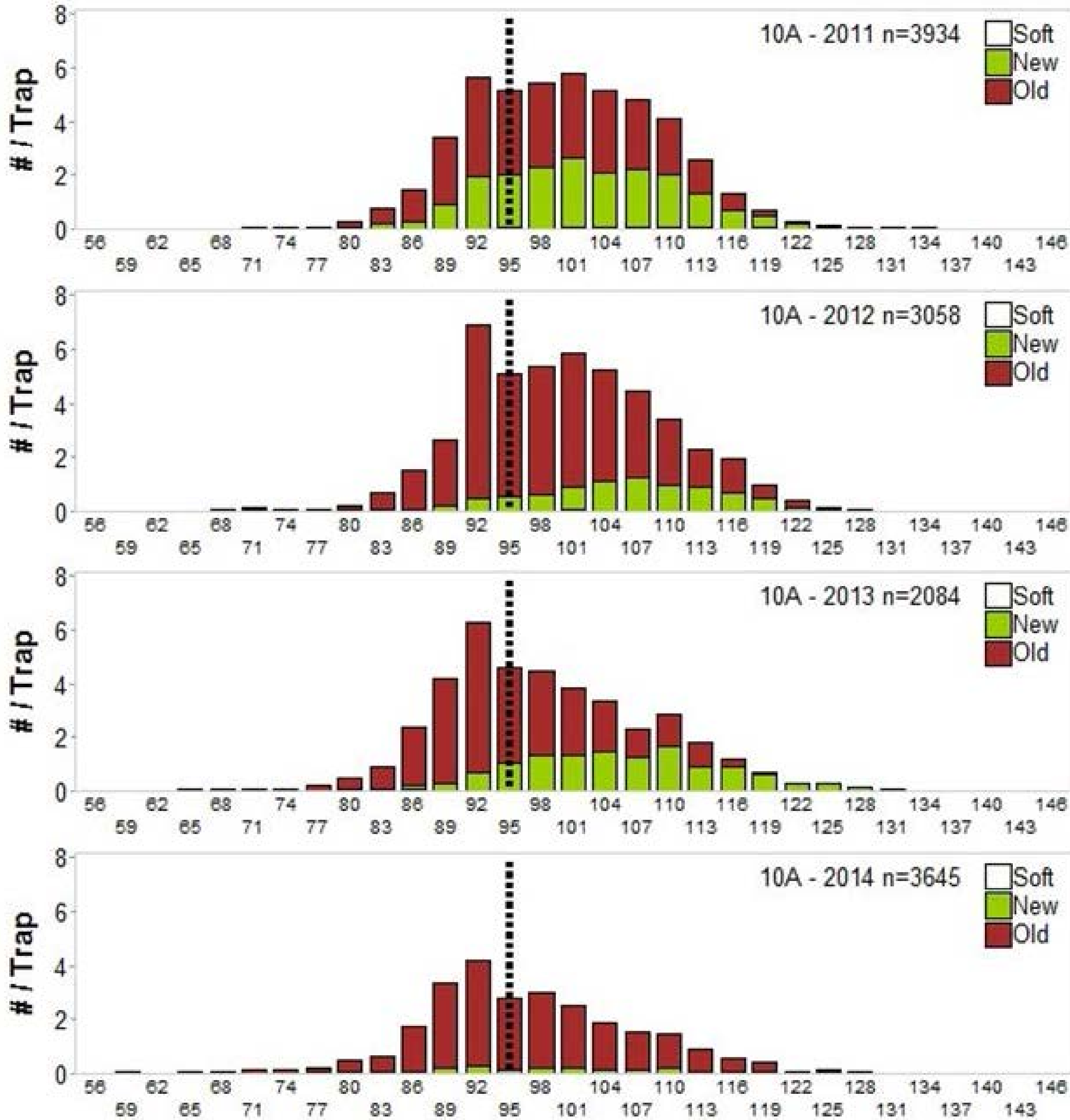


Figure 147: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 10A. The vertical dashed line indicates the minimum legal size.

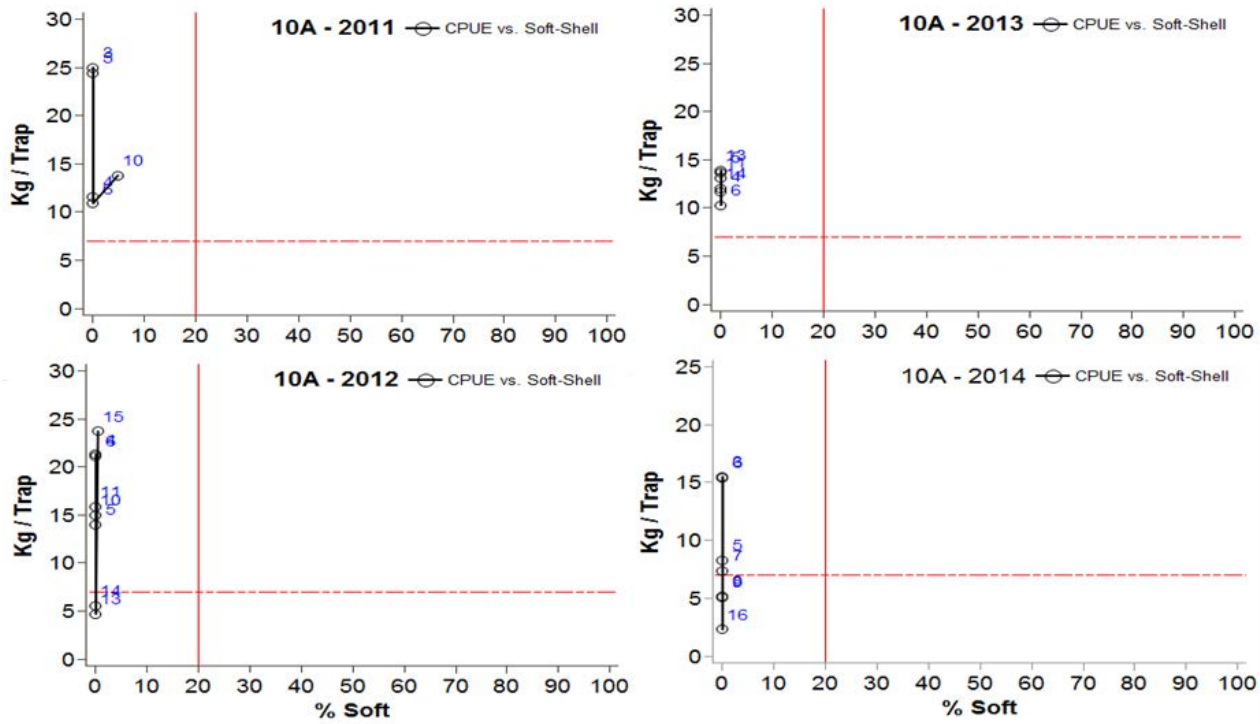


Figure 148: Trends in weekly percentages of kept vs. soft-shell crab in CMA 10A from at-sea sampling by observers.

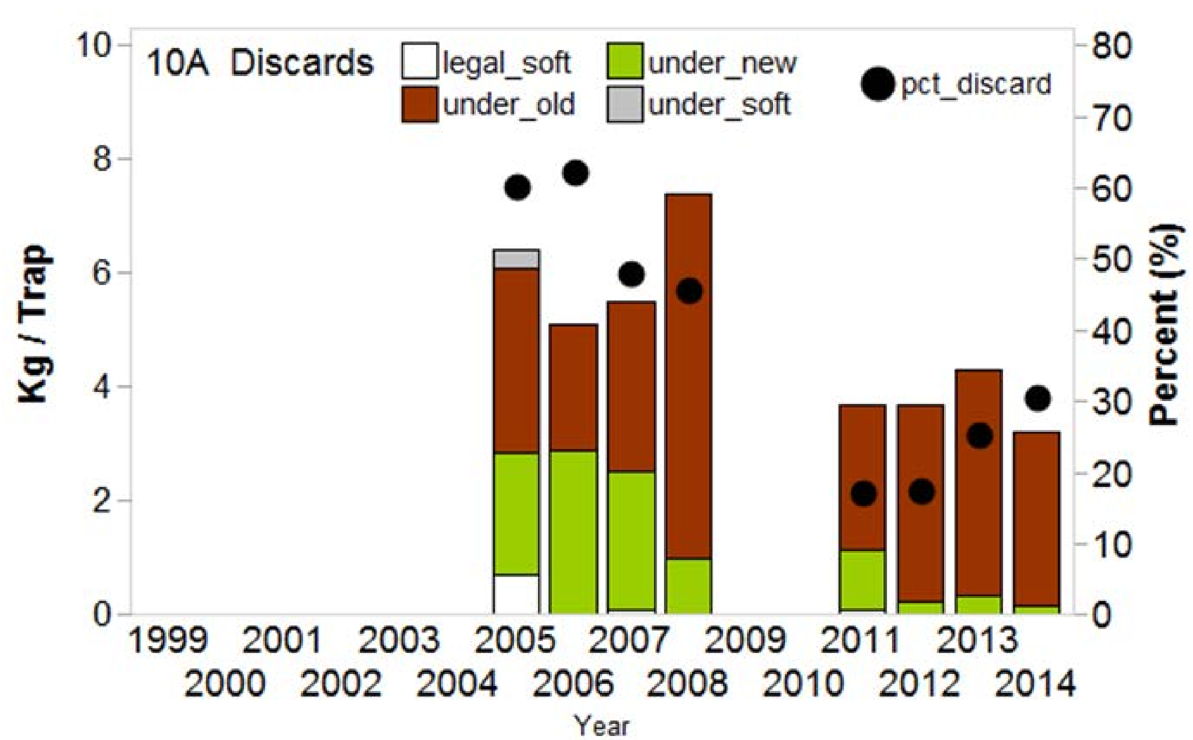


Figure 149: Trends in CMA 10A observer catch rates of total discards, undersized discards, and legal-sized discards, as well as the percentage of the catch discarded.

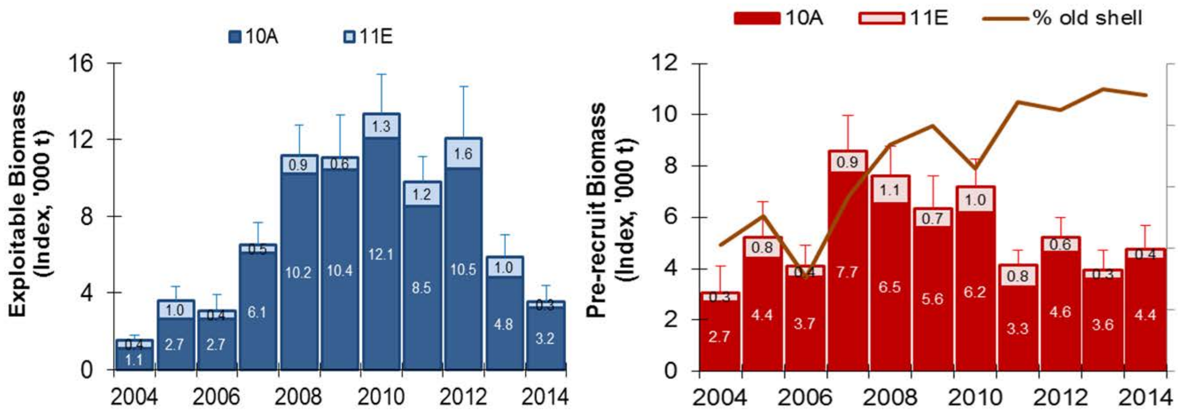


Figure 150: Subdiv. 3Ps inshore exploitable (left) and pre-recruit (right) biomass indices by CMA (left) from the CPS trap survey. The brown line on the pre-recruit plot represents the percentage of sub-legal-sized crabs that were old-shelled.

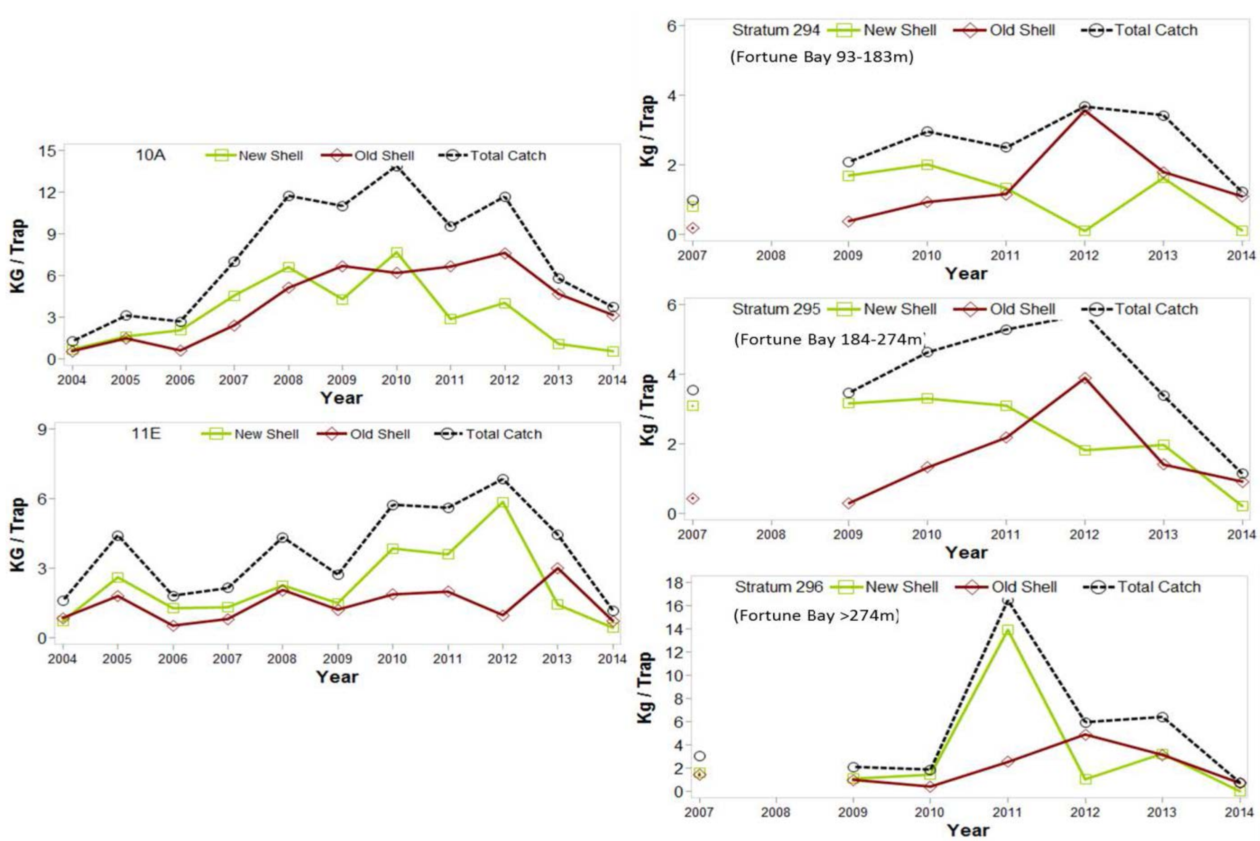


Figure 151: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in Subdiv. 3Ps inshore CMAs (left) and by strata occupied in the DFO trap survey in Fortune Bay (right).

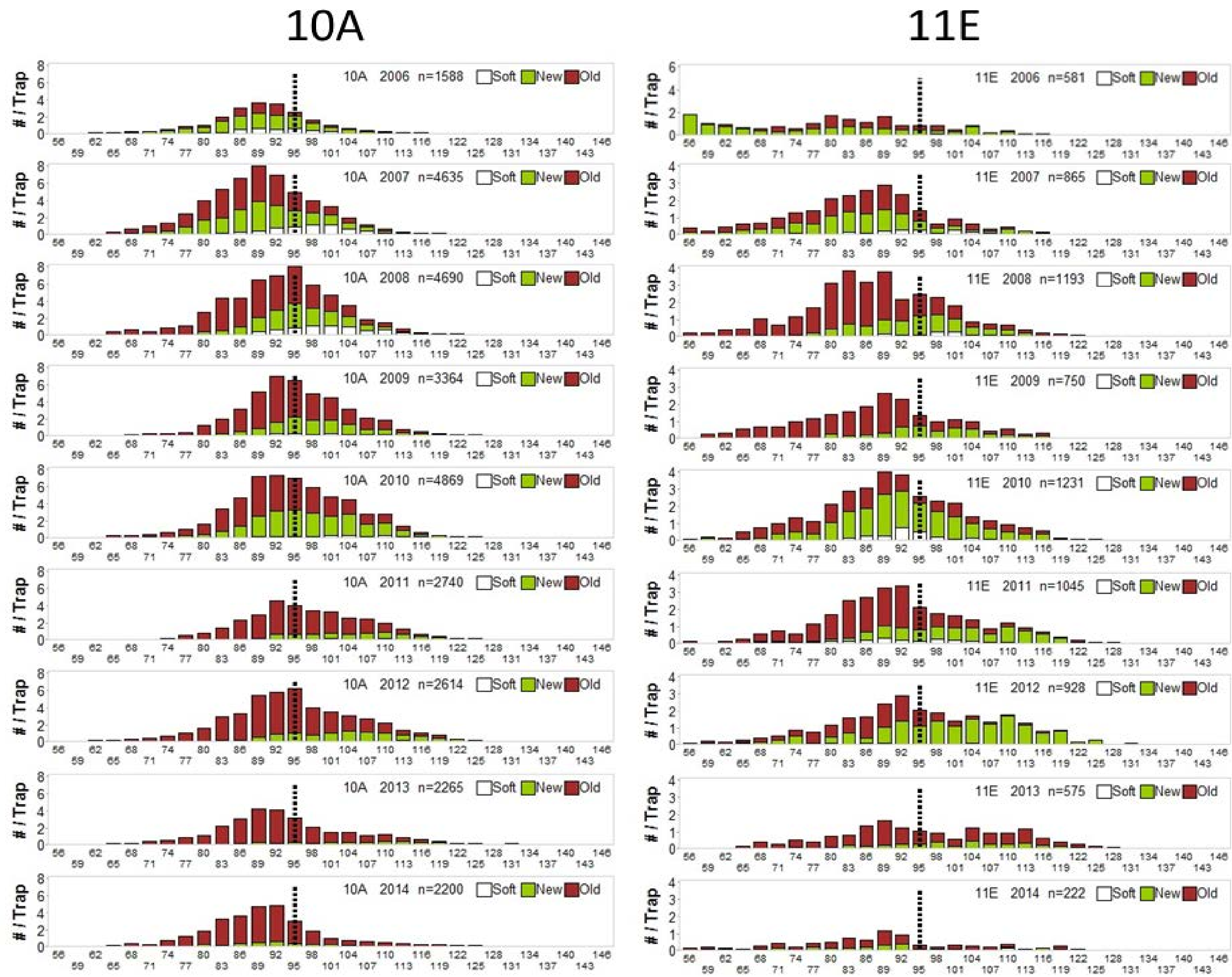


Figure 152: Trends in male carapace width distributions from large mesh traps at core stations in the Subdiv. 3Ps inshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

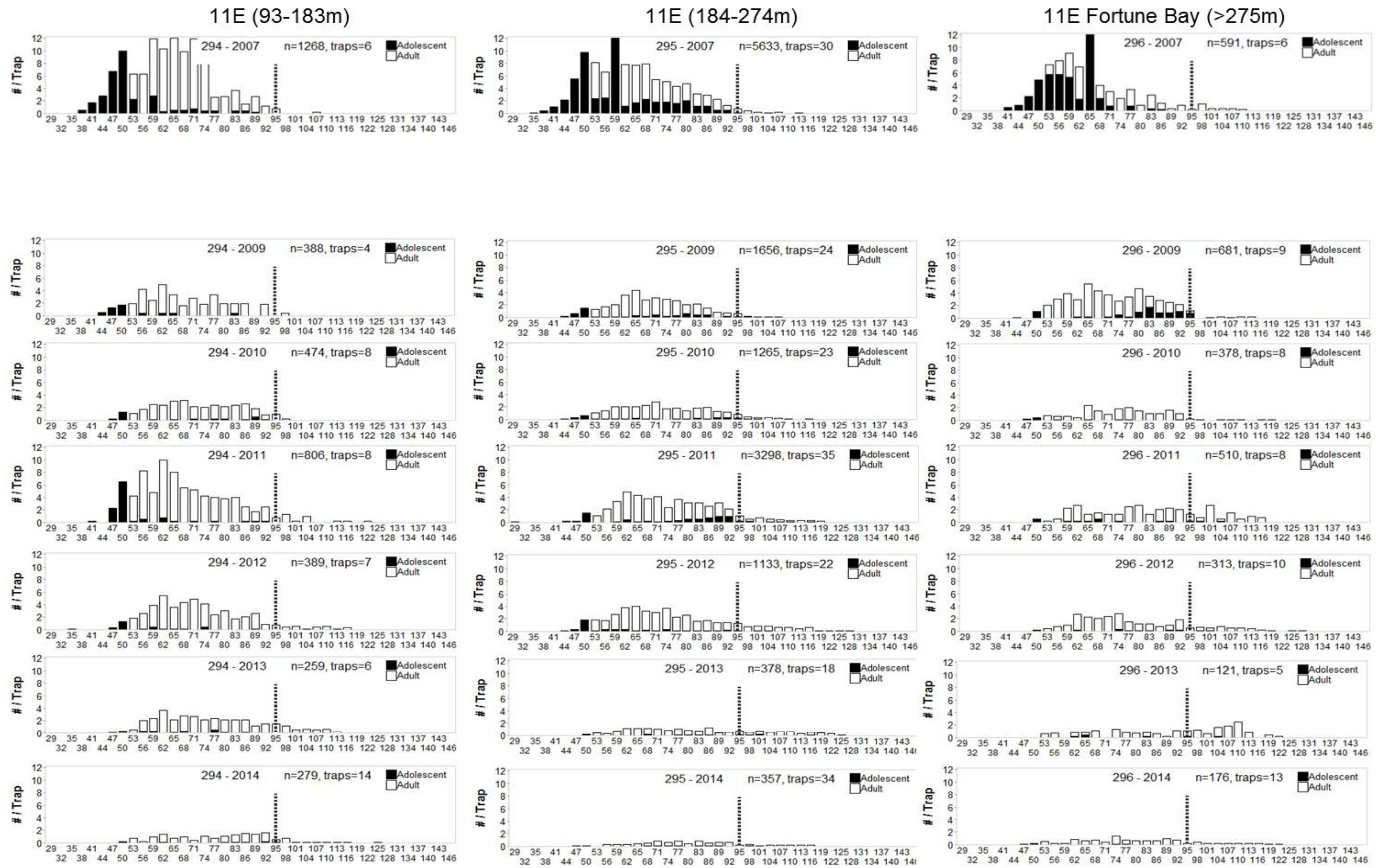


Figure 153: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in DFO trap survey in Fortune Bay. The vertical dashed line indicates the minimum legal size.

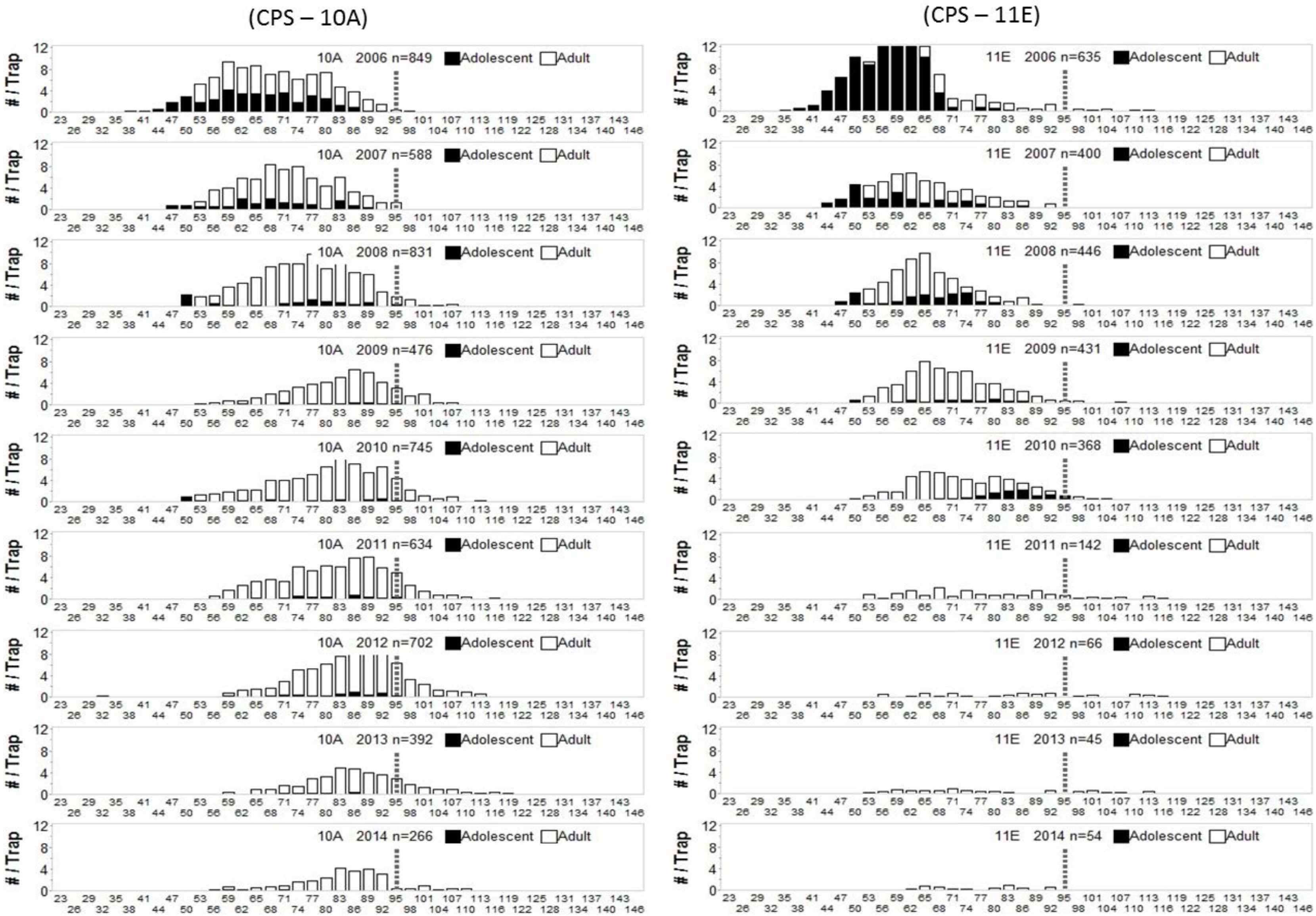


Figure 154: Trends in male carapace width distributions from small-mesh traps in the CPS trap survey by CMA. The vertical dashed line indicates the minimum legal size.

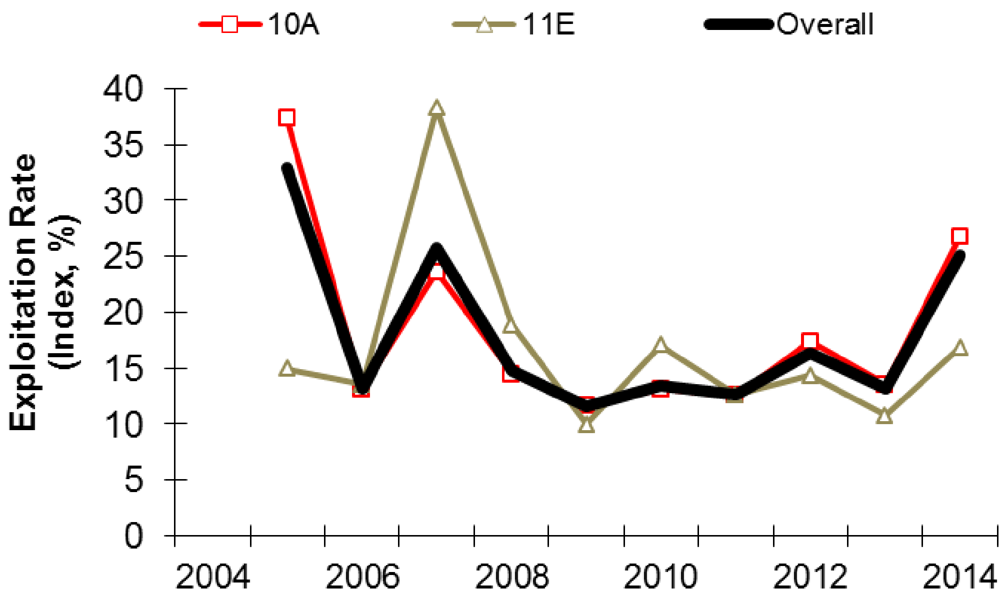


Figure 155: Exploitation rate indices by CMA as well as overall for Subdiv. 3Ps inshore based on the CPS trap survey.

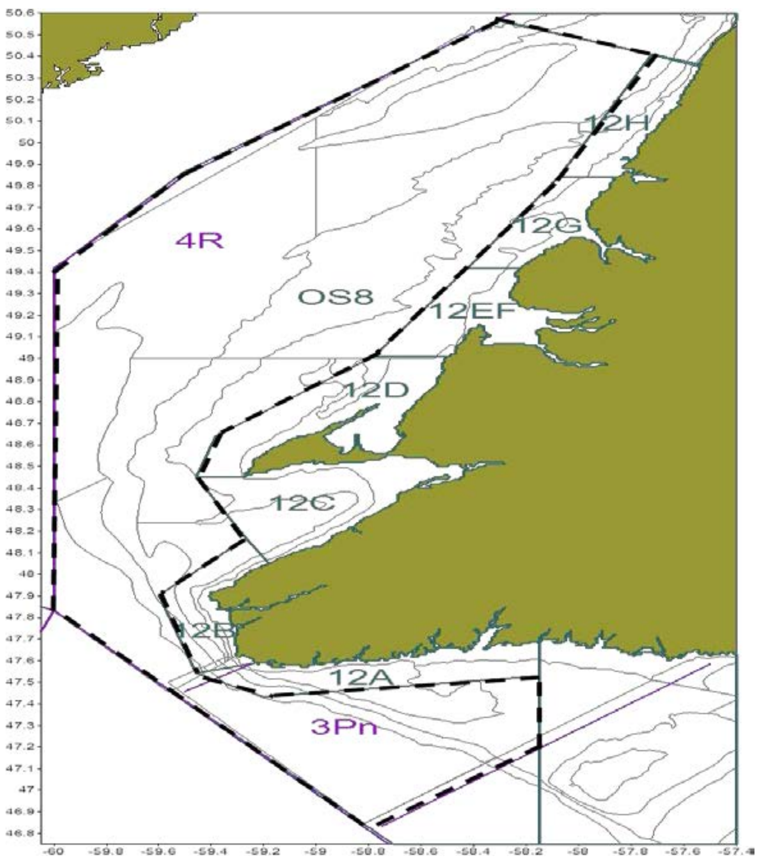


Figure 156: Map of Divs. 4R3Pn showing CMAs and important bathymetric features. Dashed perimeter indicates offshore areas.

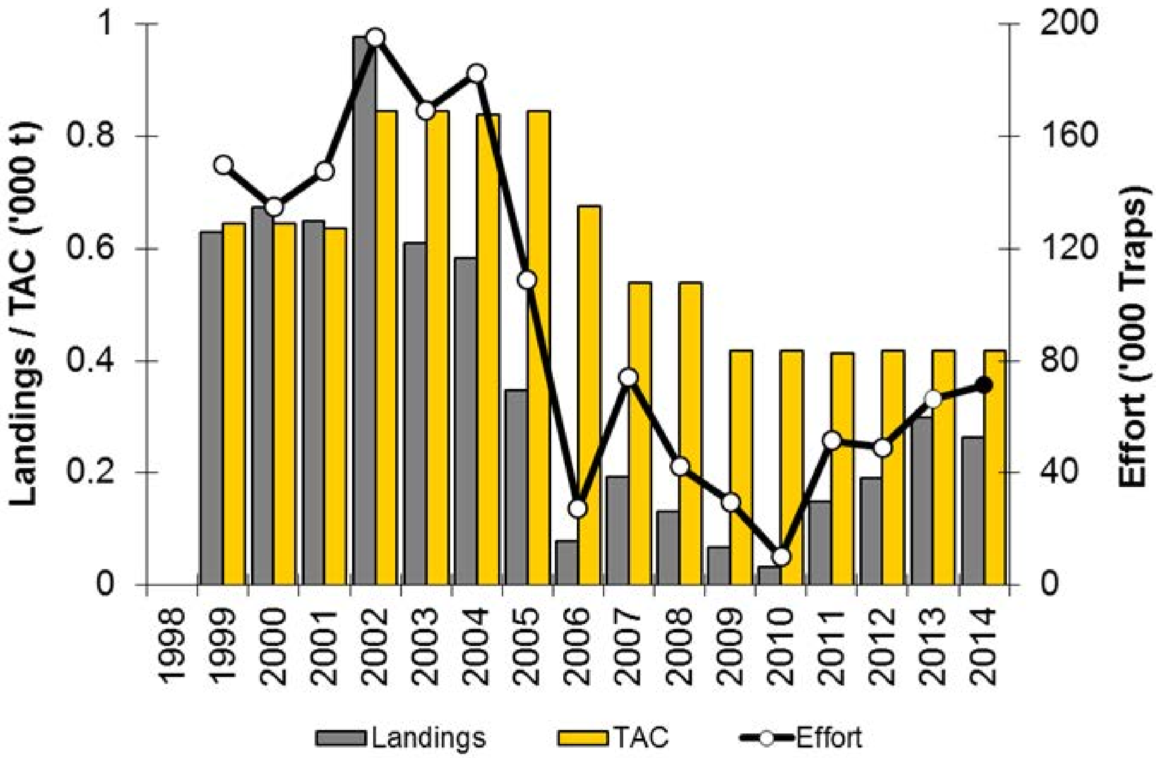


Figure 157: Trends in Divs. 4R3Pn offshore landings, TAC, and fishing effort. 2014 effort preliminary.

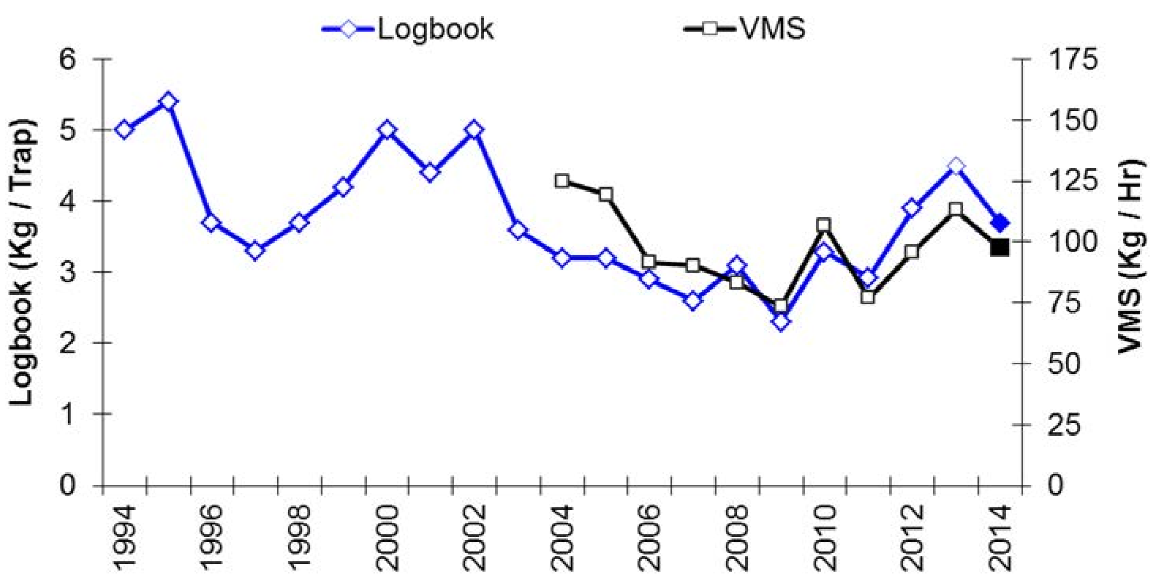


Figure 158: Trends in commercial logbook-based and VMS-based CPUE in the Divs. 4R3Pn offshore fishery. 2014 estimates preliminary.

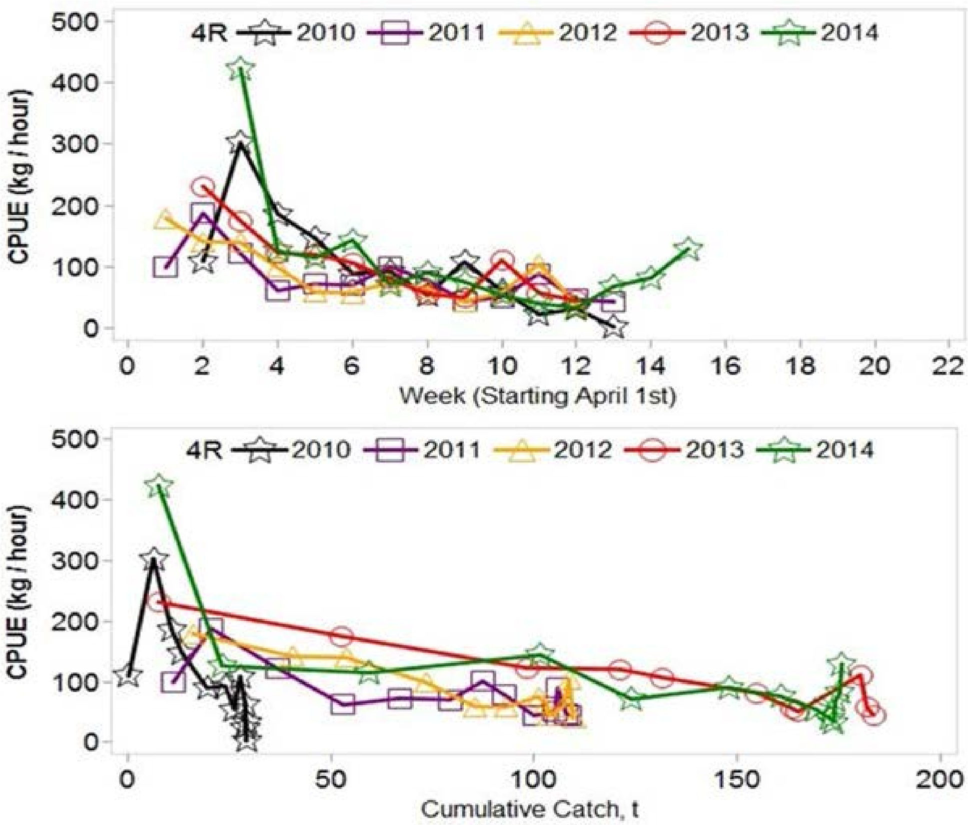


Figure 159: Seasonal trends in VMS-based CPUE for Divs. 4R3Pn offshore; by week (above), and in relation to cumulative catch (below).

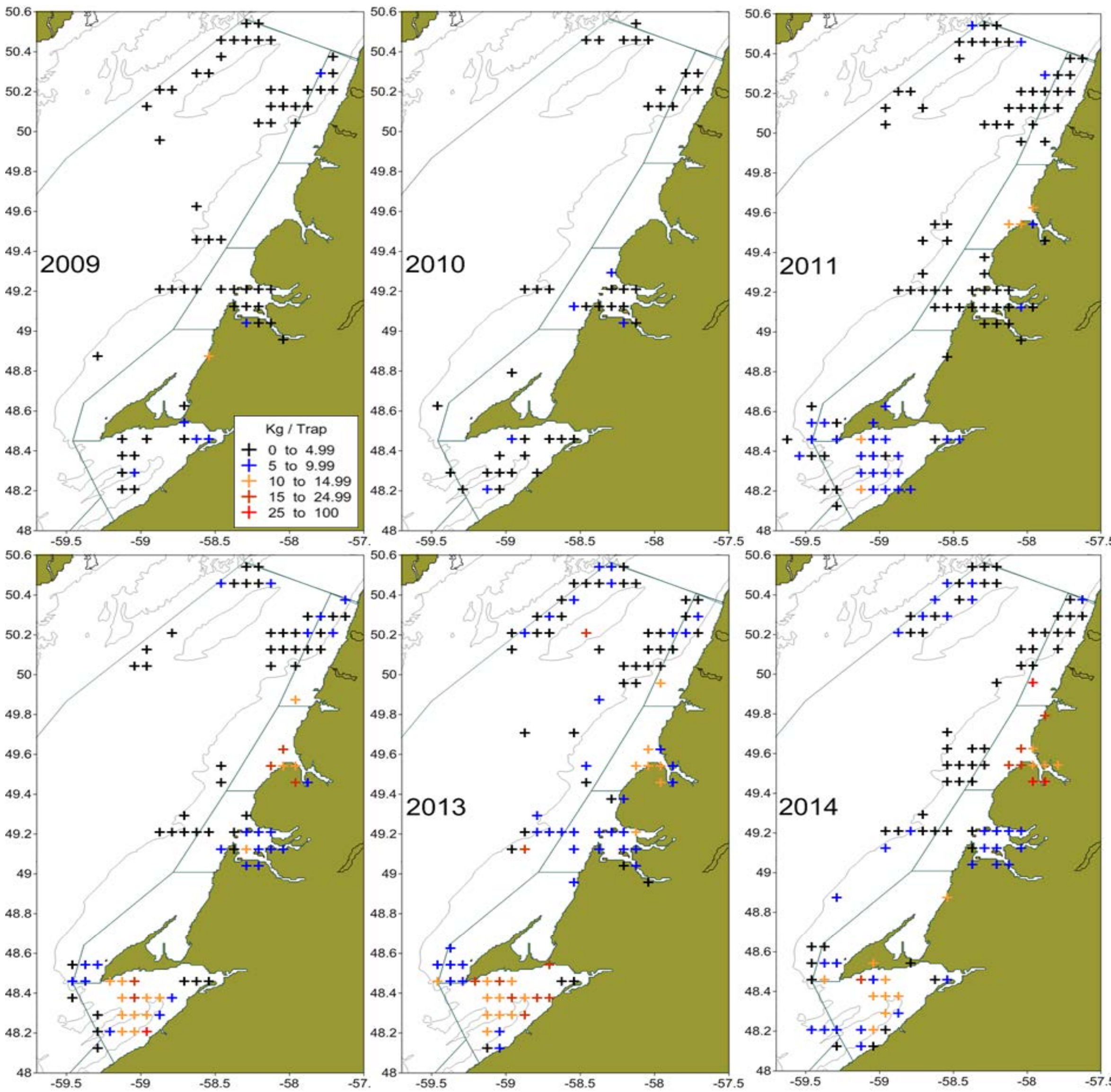


Figure 160: Spatial distribution of Divs. 4R3Pn offshore and inshore logbook CPUE by year.

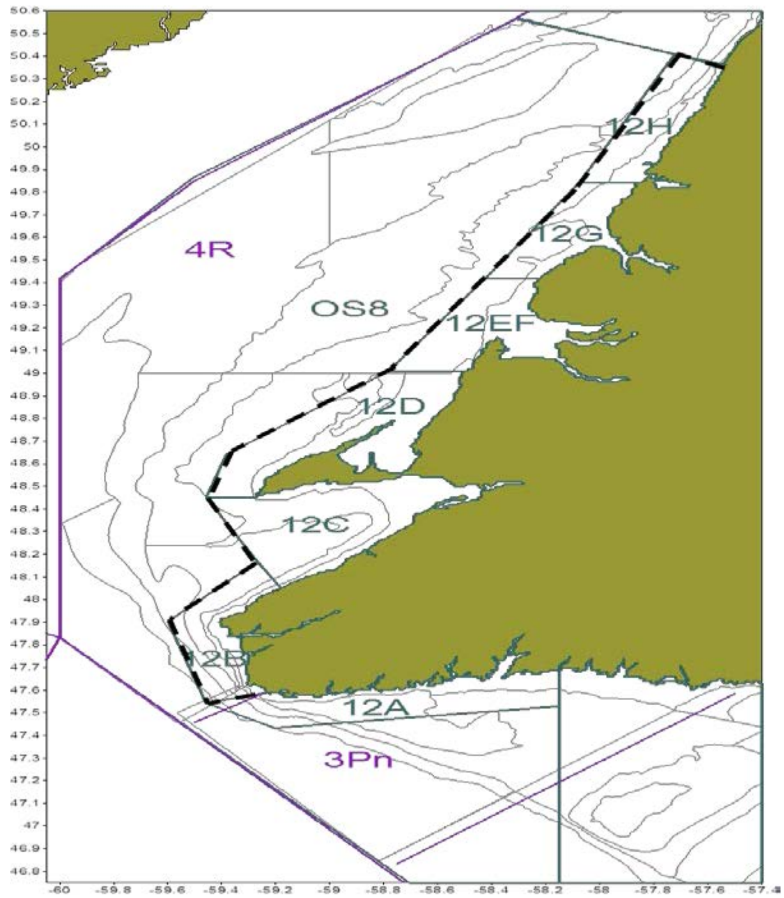


Figure 161: Map of Div. 4R showing CMAs and important bathymetric features. Dashed perimeter indicates inshore areas.

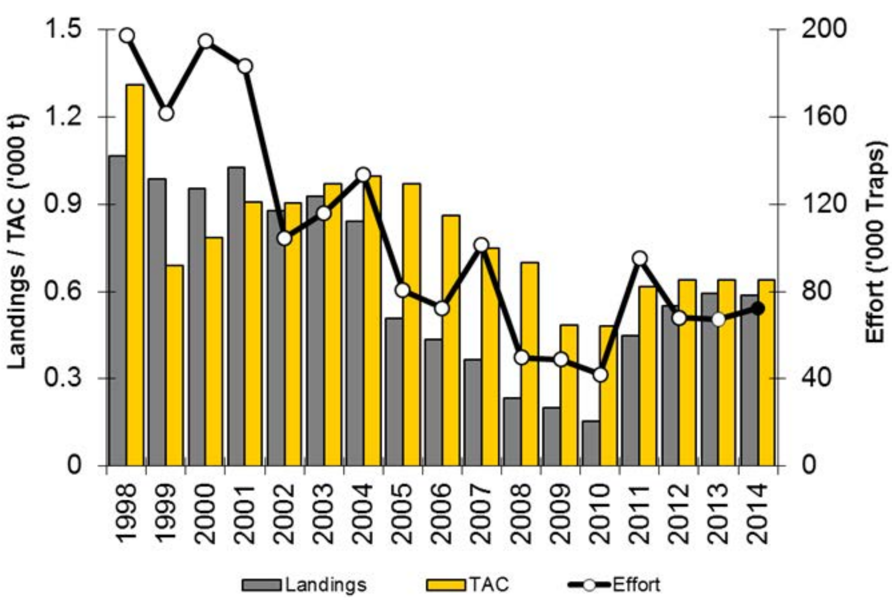


Figure 162: Trends in Div. 4R inshore landings, TAC, and fishing effort. 2014 effort preliminary.

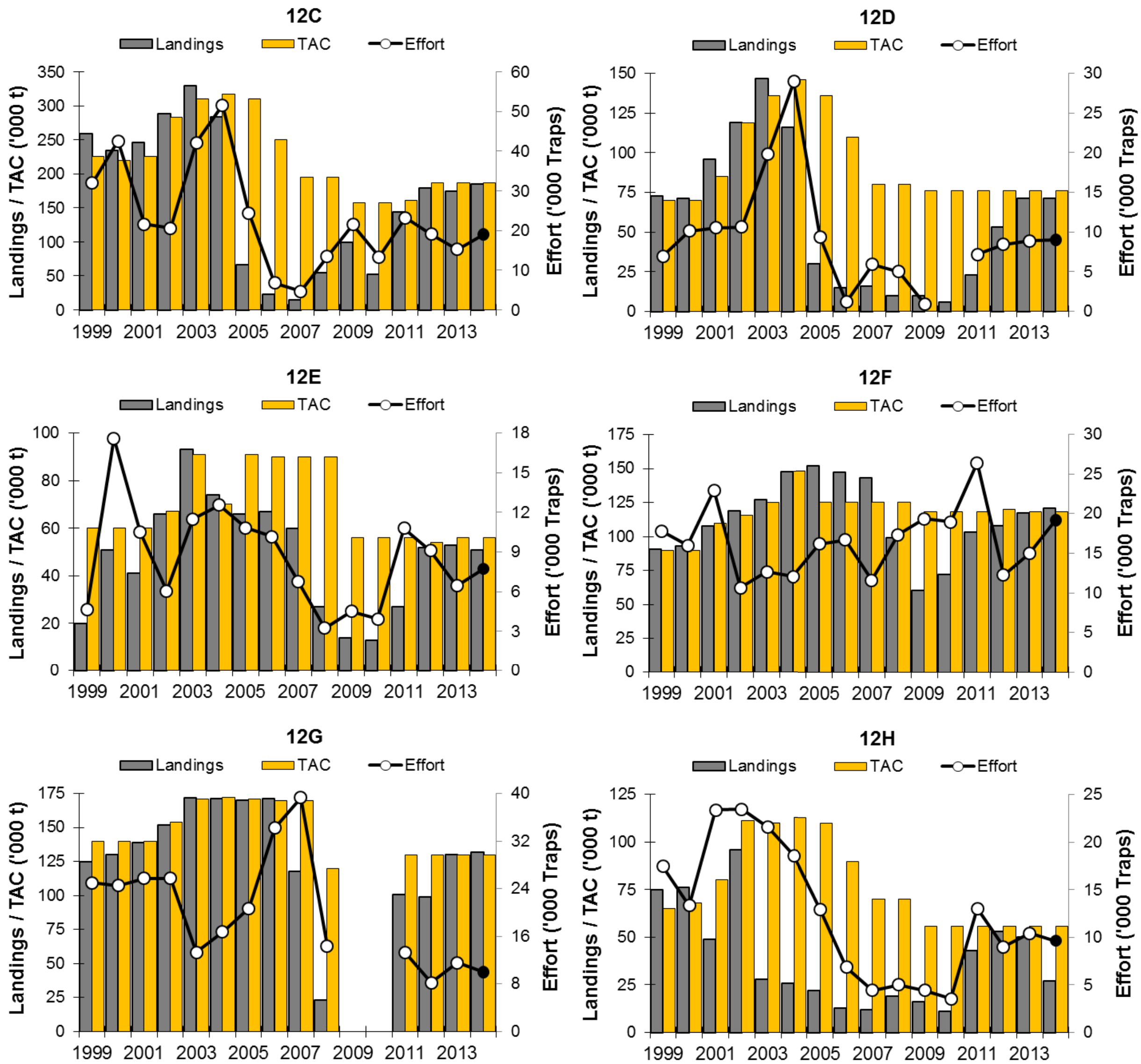


Figure 163: Trends in Div. 4R inshore landings, TAC, and fishing effort by CMA. 2014 effort preliminary.

Figure 164: Trend in commercial logbook CPUE in the Div. 4R inshore fishery. 2014 estimate preliminary

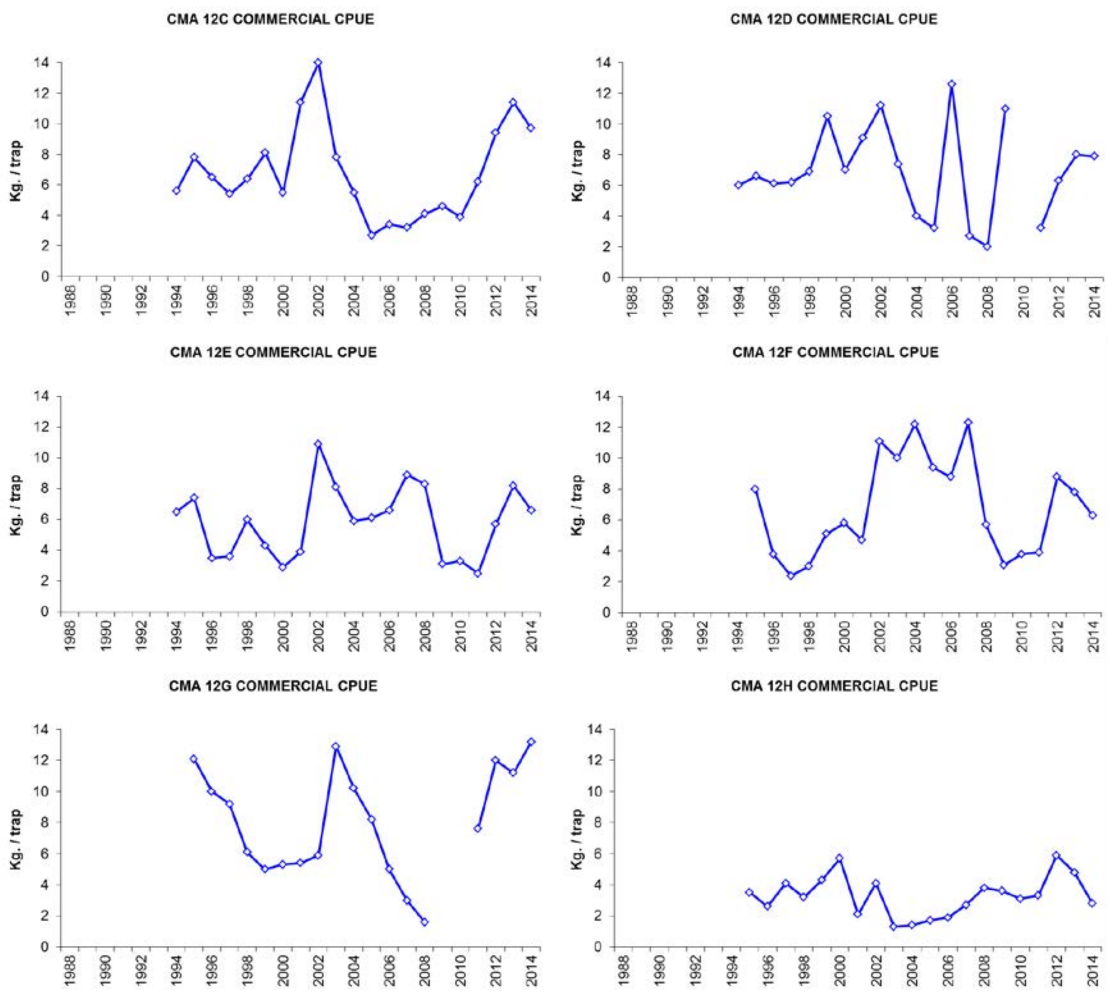


Figure 165: Trend in Div. 4R inshore logbook CPUE by CMA. 2014 CPUE preliminary.

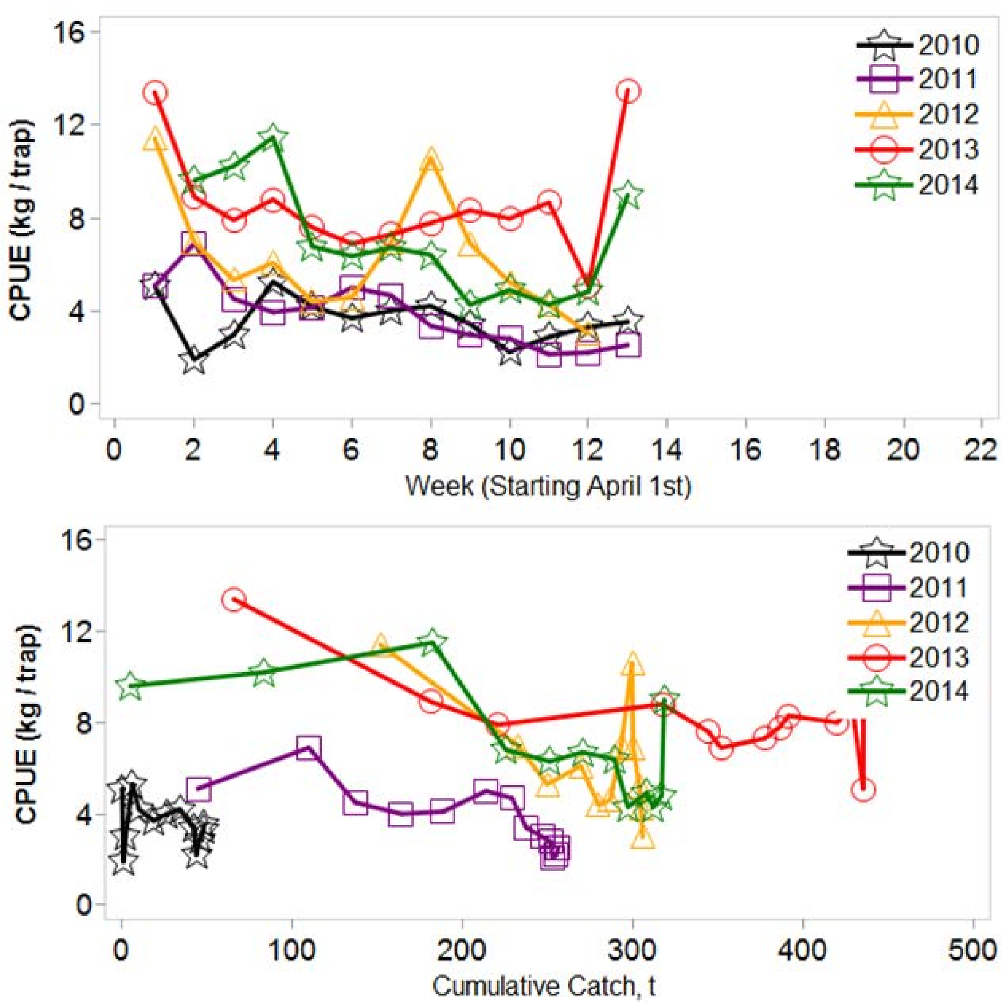


Figure 166: Seasonal trends in logbook-based CPUE for Div. 4R inshore; by week (above), and in relation to cumulative catch (below).

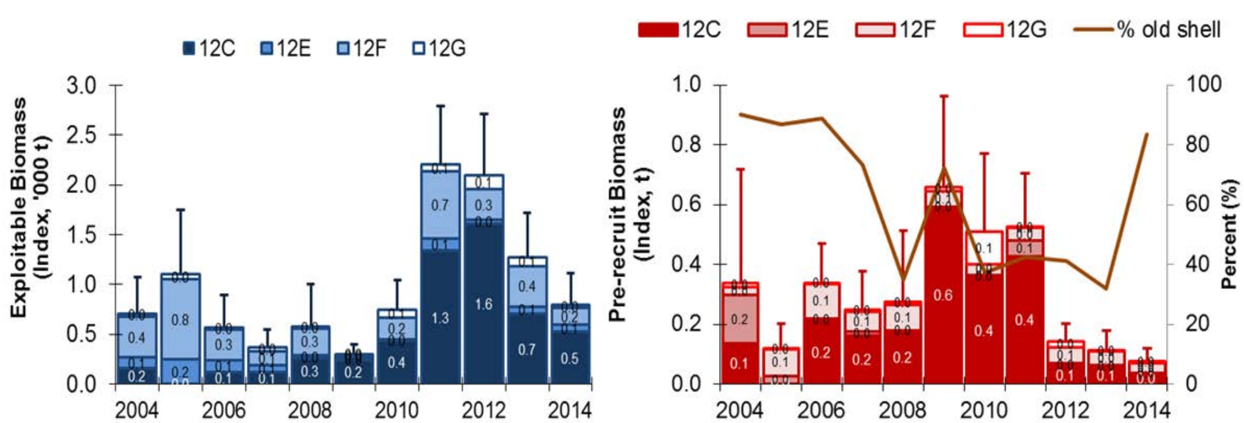


Figure 167: Div. 4R inshore exploitable (left) and pre-recruit (right) biomass indices by CMA from the CPS trap survey. The brown line on the pre-recruit plot represents the percentage of sub-legal-sized crabs that were old-shelled.

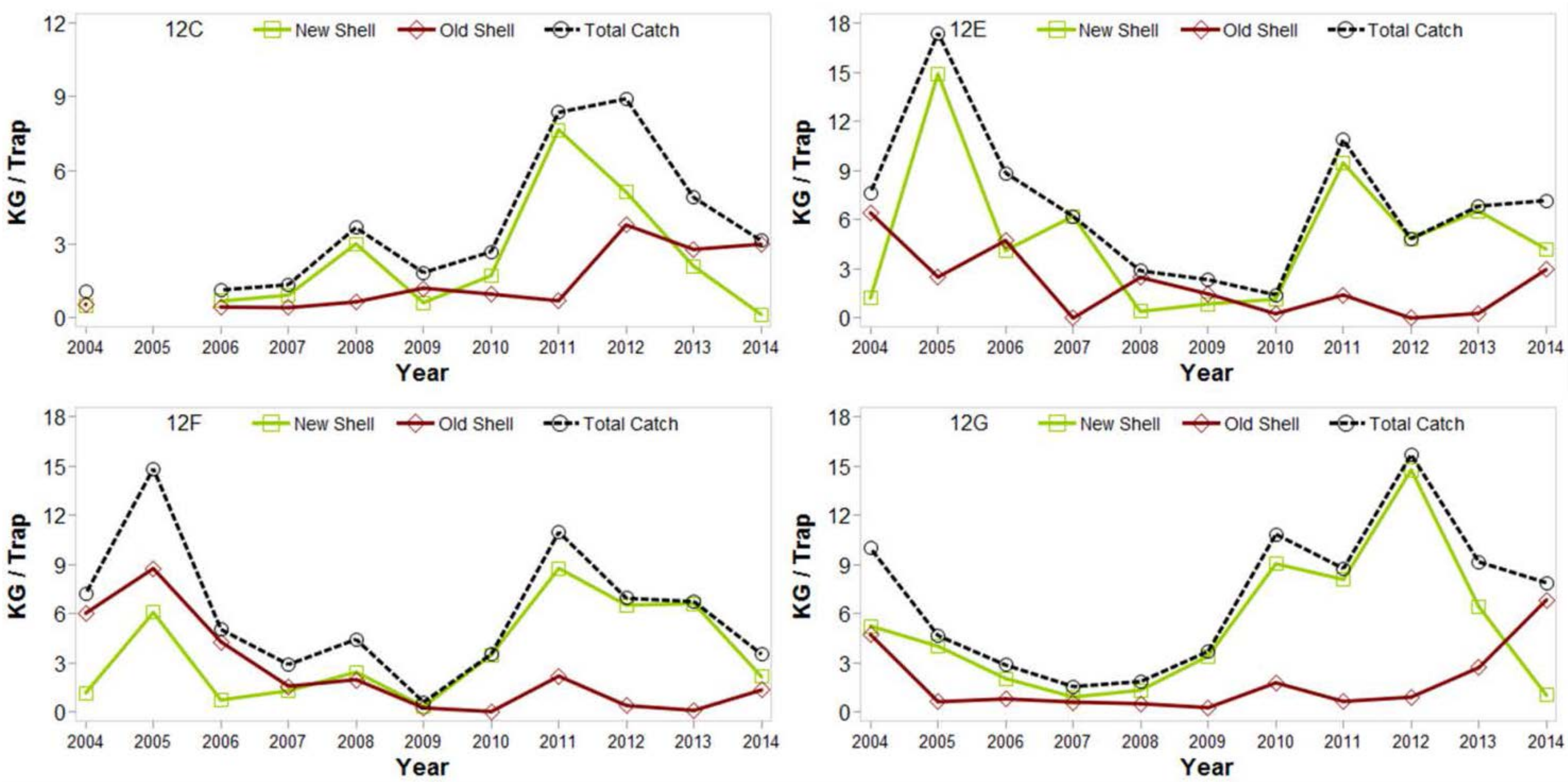


Figure 168: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in Div. 4R inshore CMAs.

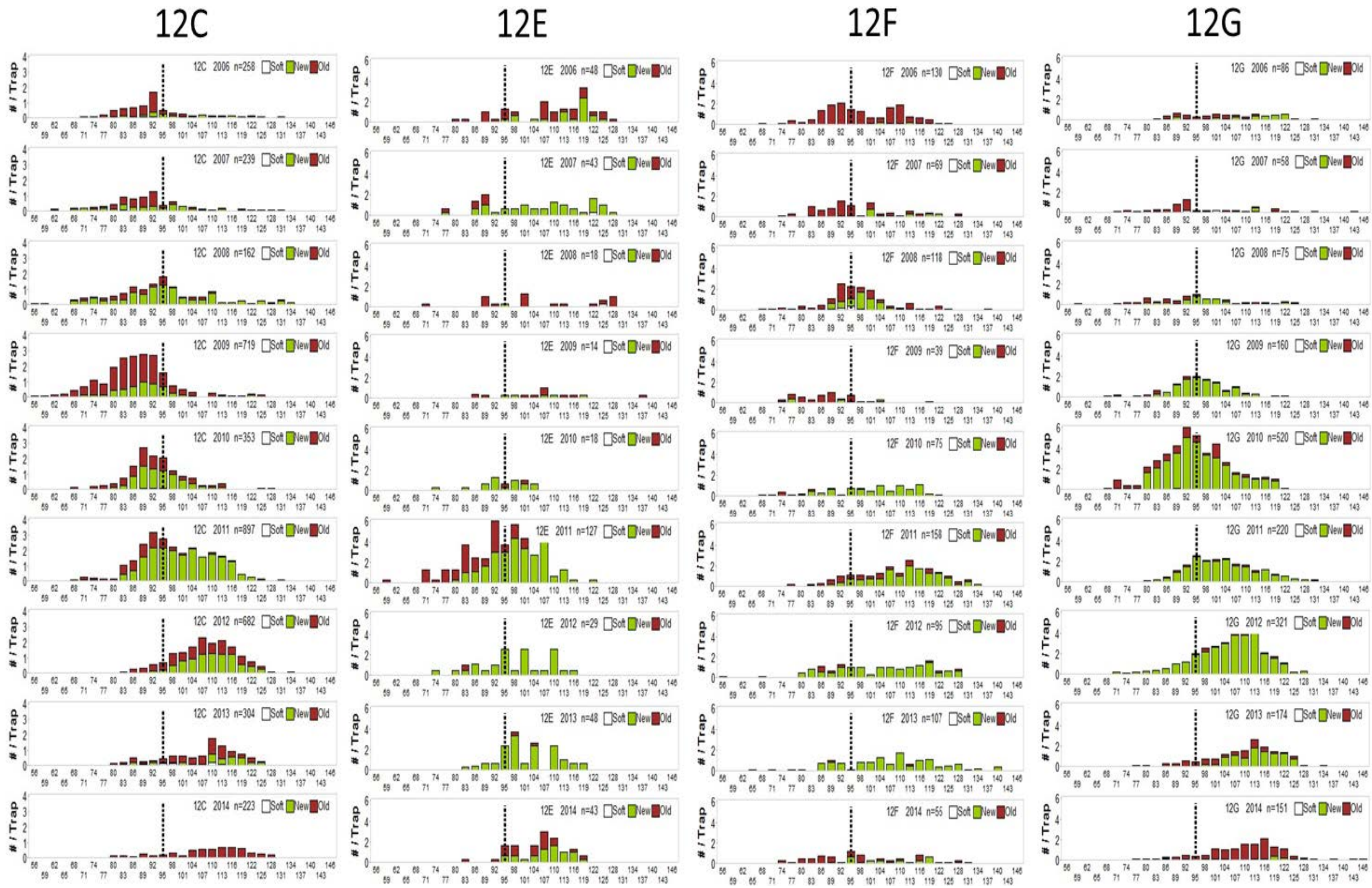


Figure 169: Trends in male carapace width distributions from core stations in the Div. 4R inshore CPS trap survey by CMA. The vertical dashed line indicates the minimum legal size.

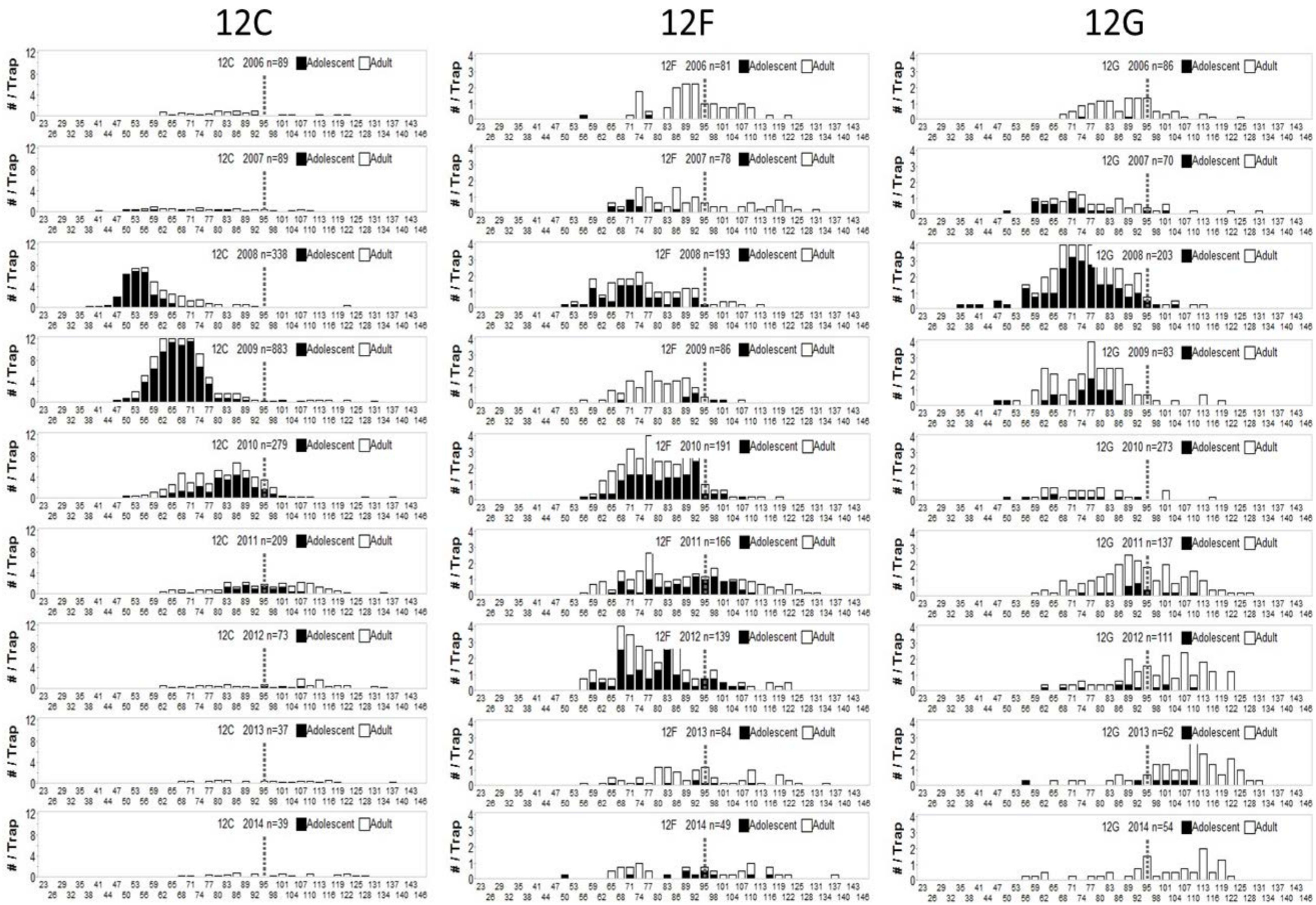


Figure 170: Trends in male carapace width distributions from small-mesh traps in the CPS trap survey by CMA. The vertical dashed line indicates the minimum legal size.

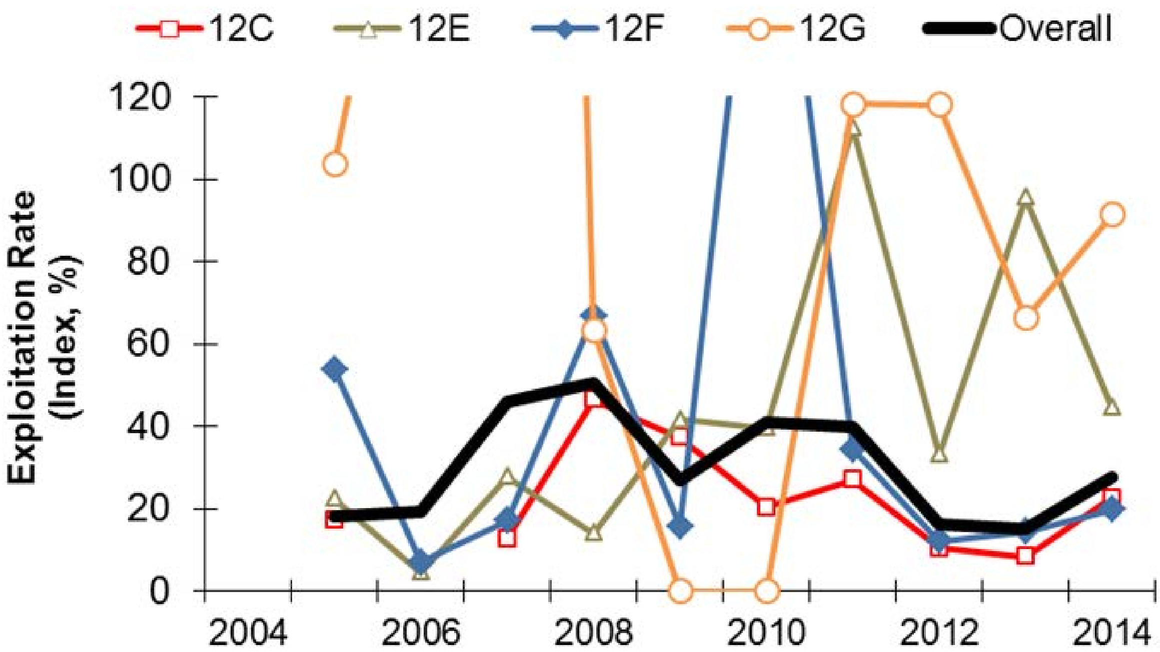


Figure 171: Exploitation rate indices by CMA as well as overall for Div. 4R inshore based on the CPS trap survey.