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Status of the Newfoundland and Labrador Snow Crab Resource in 1999

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Abstract

Data on catch rate, size (carapace width, CW) and molt status (chela allometry) from various sources were used to infer resource status of Newfoundland and Labrador snow crab (*Chionecetes opilio*). Data from 1995-99 fall bottom trawl surveys throughout Div. 2GHJ3KLMNO were particularly useful. These surveys are conducted near the end of the fishing season and so are considered to provide an index of residual biomass. Legal-sized males were broadly distributed throughout much of the survey area but were absent from Div. 2GH and 3M, some inshore areas, and across much of the shallow southern Grand Bank. The exploitatable biomass available to the Div. 2J3KLNO fishery in 2000 was projected to be about half that of the previous year due to substantial decreases in both recruitment and the residual biomass. A regular decline in abundance of smallest males since 1996 implies that recruitment will continue to decline for several years. Biomass of mature females has declined since 1995 in Div. 2J3KLNO. September inshore Div. 3K surveys showed that intermediate-sized males (about 40-75 mm) predominated in both small-meshed trap and Campelen trawl catches and were particularly abundant in the shallowest strata. Trap survey catch rates of such intermediate-sized crabs in White Bay increased regularly during 1995-98 but declined in 1999, possibly reflecting density-dependent and size-related changes in distribution patterns in recent years. Incidence of bitter crab disease (BCD) in the September trap survey has increased in legal-sized males since 1996 but also increased in smallest males in 1999. Spatial BCD trends from fall Div. 2J3KLNO bottom trawl surveys suggest a northward shift of highest prevalence during 1997-99. BCD may be under-represented in research samples and could represent an important source of mortality to small crabs of both sexes. Biomass estimates from 1996-99 spring Div. 3Ps bottom trawl surveys were unrealistically low, highly variable, and unreliable.

Résumé

Obtenues de diverses sources, des données sur le taux de capture, la taille (largeur de carapace, LC) et la mue (allométrie des chélipèdes) du crabe des neiges (*Chionecetes opilio*) de Terre-Neuve et du Labrador sont utilisées pour déduire l'état de cette ressource. Les données des relevés au chalut de fond effectués de 1995 à 1999 dans l'ensemble des divisions 2GHJ3KLMNO se sont avérées particulièrement utiles. Comme ces relevés ont été réalisés vers la fin de la saison de pêche, on considère qu'ils fournissent un indice de la biomasse qui reste après la pêche. Des mâles de taille légale étaient largement répartis dans une grande partie de la zone des relevés, mais ils étaient absents des divisions 2GH et 3M, de certains secteurs côtiers et d'une grande partie du secteur sud peu profond du Grand Banc. La prévision de la biomasse exploitable disponible pour la pêche dans les divisions 2J3KLNO en 2000 représente environ la moitié de la biomasse disponible l'année précédente; cette baisse est attribuable à des réductions importantes du recrutement et de la biomasse qui reste après la pêche. La baisse graduelle de l'abondance des plus petits mâles observée depuis 1996 laisse prévoir que le recrutement continuera de diminuer pendant plusieurs années encore. Dans les divisions 2J3KLNO, la biomasse des femelles matures diminue depuis 1995. Dans des relevés effectués en septembre dans la zone côtière de la division 3K, les mâles de taille intermédiaire (d'environ 40 à 75 mm) étaient dominants dans les casiers à petit maillage et les prises au chalut Campelen; ils étaient particulièrement abondants dans les secteurs les moins profonds. Les taux de capture de crabes de taille intermédiaire observés lors de relevés par casiers réalisés dans la baie White ont augmenté régulièrement de 1995 à 1998, mais ils ont baissé en 1999, peut-être en raison de changements de la répartition géographique liés à la taille et à la densité dépendance qui se seraient produits au cours des dernières années. L'incidence de la maladie du crabe amer (MCA «BCD») observée dans les relevés par casiers de septembre a augmenté chez les mâles de taille légale depuis 1996; toutefois, elle a aussi progressé chez les plus petits mâles en 1999. Les tendances spatiales de l'incidence de la MCA observée dans les relevés au chalut de fond pour les divisions 2J3KLNO laissent croire que la zone de prévalence maximale s'est déplacée vers le nord de 1997 à 1999. La MCA étant peut-être sous-représentée dans les échantillons des relevés, elle pourrait constituer une importante cause de mortalité de petits crabes des deux sexes. Comme les estimations de la biomasse à partir des relevés au chalut de fond effectués au printemps, de 1996 à 1999, dans la sous-division 3Ps sont excessivement basses et très variables, on ne peut s'y fier.

Introduction

This document presents research data from various sources toward evaluating the status of the Newfoundland and Labrador snow crab (*Chionecetes opilio*) resource in 1999 and projecting change in resource level for the 2000 fishery. Data sources include the fall 1995-99 multispecies bottom trawl surveys throughout NAFO Div. 2GHJ3KLMNO and spring 1996-99 Div. 3Ps bottom trawl surveys. Data are also presented from NAFO Div. 3K September trap and trawl surveys in White Bay during 1994-99 and in Notre Dame Bay during 1996-99. These data sources have been used in annual snow crab assessments since 1997 (Dawe et al. 1997, 1998, 1999).

Methods

Bottom Trawl Surveys

Data Collected:

Data on total catch number and weight were acquired from the 1995 to 1999 fall stratified random bottom trawl surveys, which extended throughout NAFO Div. 2J3KLMNO. The 1996-98 surveys also extended to NAFO Div. 2GH and to inshore strata, not included in the 1995 and 1999 surveys. Data were also acquired from 1996-99 NAFO Div. 3Ps spring bottom trawl surveys. These surveys utilized the Campelen 1800 survey trawl in standard tows of 15 min. duration.

All males were measured in carapace width (CW, mm) and chela height (CH, 0.1 mm). Shell condition was assigned one of three categories: (1) new-shelled - these crab had molted in spring of the current year, have a low meat yield throughout most of the fishing season, and are generally not retained in the current fishery until fall; (2) intermediate-shelled – these crab last molted in the previous year and are fully recruited to the fishery throughout the current fishing season; (3) old-shelled – these crab have been available to the fishery for at least 2 years. Occurrence of bitter crab disease (BCD) was also noted. BCD is caused by the hemoparasitic dinoflagellate *Haematodinium spp*.. Infected crabs are recognized by orange-pink coloration on the dorsal surface and an opaque white ‘cooked’ appearance to the ventral surface.

Treatment of Biological Data:

A schematic model of snow crab recruitment (Dawe et al. 1997) was followed in assigning individuals to population components for subsequent analysis. Based on this model, data were grouped into classes for each of three biological variables:

i) Carapace Width (CW) – based on growth per molt data (Moriyasu et al. 1987, Taylor and Hoenig 1990, and Hoenig et al. 1994), three main size groups were established: legal-sized crabs (≥95 mm CW); Sub-legal 1, those which would achieve legal size after one molt (76-94 mm CW); and Sub-legal 2, those which would achieve legal size after two molts (60-75 mm CW). All other males were pooled into a category of small males (<60 mm CW). This group was divided into two groups (40-59 mm CW and <40 mm CW) to describe the effect of size on incidence of BCD from fall bottom trawl surveys.

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

iii) Shell Hardness – males that undergo their terminal molt in the spring will remain new-shelled throughout the fishery season of that year and will not be fully hardened until the following year. For practical purposes new-shelled legal-sized crabs are considered to be part of the exploitable biomass, although it is recognized that they are not retained by the fishery early in the season. It is assumed that all males with small chelae 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, it’s eventual recruitment is delayed by a year.

Analysis of Data:

Spatial distribution was examined for Div. 2GHJ3KLNO using the fall survey data for 1995-99 and, for Div. 3Ps, using the spring 1996-99 survey data. ACON (G. Black, pers. com.) was used to describe density distribution of each of four size groups of males; legal-sized (>94 mm CW), Sub-legal 1 (76-94 mm CW, Sub-legal 2 (60-75 mm CW) small males (<60 mm CW). Distribution of mature females was also described.

Minimum trawlable biomass estimates were generated using STRAP (Smith and Somerton 1981) separately for legal-sized males and for mature females. Biomass estimates for each group were generated by NAFO Division using 1995-99 fall survey data for Div. 2J3KLNO and using 1996-99 spring survey data for Div. 3Ps. Inshore Div. 3KL strata were not included in the fall Div. 2J3KLNO survey for 1999 and so their contribution to the total Div. 2J3KLNO fall biomass in 1998 is noted to facilitate direct comparison.

To examine size composition of males, carapace widths were grouped into 3 mm intervals and adjusted up to total population abundance. Each size interval was partitioned by claw type.

An initial exploitable biomass index was calculated for the following year from each yearly set of Div. 2J3KLNO fall survey data. This index was comprised of three components;

i) Standing stock component; Survey biomass of 'residual' large-clawed (terminally-molted) legal-sized (>94 mm) males.
ii) Growth component; Biomass calculated after applying a growth increment of 19 mm to 'residual' legal-sized (>94 mm) small-clawed males.
iii) Recruitment component ; Biomass calculated after applying a 19 mm growth increment to prerecruits (76-94 mm small-clawed males).

Projection of annual exploitable biomass indices does not account for annual variability in natural mortality, in proportion of small-clawed males (both legal-sized and prerecruit) that do not molt in the following spring (skip-molters), or in size-at-terminal molt.

NAFO Div. 3K Inshore Sampling

A survey was carried out during September of 1994-99 in White Bay (inshore Div. 3K, Fig. 1). Each set, at depths of 183 m and greater, was comprised of 6 baited traps separated by 45 m. The catches from end traps (large-meshed) were not sampled. The 4 traps sampled in each set included 2 large-meshed (130 mm) traps, and 2 small-meshed (25 mm) traps. Sets were apportioned among three depth strata (201-300 m, 301-400 m, and 401-500 m), and were randomly allocated within each stratum. During 1997-99 the survey also extended to Notre Dame Bay where two depth strata (201-300 m and 301-400 m) were sampled (Fig. 1) using the same sampling protocol. In September of both 1998 and 1999 comparative sampling was conducted between traps and the Campelen 1800 survey trawl, toward estimating trawl catchability for snow crab. Comparative sets were conducted in 1998 on each of 40 stations, 8 in each of the 3 White Bay and 2 Notre Dame Bay strata described above**.** Only 24 of the 40 trap stations were also sampled with the trawl in 1999 due to gear conflicts. Biological sampling and grouping of crabs by size followed the same protocols as outlined above for bottom trawl surveys.

Results and Discussion

NAFO Div. 2GHJ3KLMNO Fall Bottom Trawl Surveys

Spatial Distribution:

The fall distribution of males throughout NAFO Div. 2GHJ3KLMNO in 1999 was similar in many respects to that during 1996-98 (Fig. 2), as previously described (Dawe et al. 1999). Males were broadly distributed throughout the Div. 2J3KLNO survey area but were absent from more northern (Div. 2GH) and eastern (Div. 3M) areas. They were also absent from most of the deepest sets (mostly >800 m) along the Div. 3KL slope. Largest males (legal-size and Sub-legal 1, Fig. 2a-b) were also usually absent from innermost sets at depths <300 m in Div. 2J3K where smaller males were caught (Fig. 2c-d). For all years crabs were virtually absent over a broad area of the shallow (<100 m) southern Grand Bank (Fig. 2).

Despite these similarities among years, there were also differences. The male distribution pattern had been gradually changing over the period 1995-98 for all size groups (Dawe et al. 1999 and Fig. 2). Highest densities of largest (legal-sized) males expanded from northern Div.3L in 1995 (Dawe et al. 1999) northward throughout Div. 2J3K, as well as to the south along the Div. 3LNO eastern slope of the Grand Bank (Fig. 2a). Highest densities of smallest males (<60 mm), located in northern Div. 3L and southern Div. 3K in 1995 (Dawe et al. 1999) also expanded northward throughout Div. 2J3K during 1996-98 but densities decreased greatly along the eastern Div 3LNO Slope (Fig. 2d).

These changes in distribution of largest males could be accounted for by annual area-specific changes in exploitation rate relative to recruitment level. However this would not account for similar trends in the smaller size groups. The apparent northward shift of smallest crabs <60 mm CW (Fig. 2d) could be accounted for by area-specific variation in production or early survival, but this is not consistent with the general similarity in trends among all size groups. It is likely that distribution patterns are also affected by environmental variation, variable mortality, and density dependent processes.

Density dependent effects are suggested by comparison of distribution patterns among male size groups during 1995-98. In 1995 (Dawe et al. 1999) and 1996 small males (Fig. 2c-d) were largely sympatric with large males (Fig. 2 a-b), with highest densities in offshore deep strata and slope areas. However in 1997 and 1998 segregation became more evident due to a shift of highest densities of small males to inshore areas and shallow offshore banks (Fig. 2 c-d).

The distribution pattern of males changed considerably in 1999 from the 1995-98 trends (Fig. 2). The density of largest (legal-sized) males decreased overall in 1999, especially in northern Div. 2J3K (Fig. 2a) whereas density of smaller sub-legal 1 males (76-94 mm) also decreased greatly along the eastern Div. 3LNO slope (Fig. 2b). The greatest change was in density of smallest males (<60 mm), which increased considerably in Div. 3LO, decreased markedly in Div. 3K, and changed relatively little in Div. 2J. Changes in distribution for such small males are not directly related to the fishery. Such sharp annual and area-specific changes in density imply great spatial variation in production or mortality of young crab.

Mature females were overall as broadly distributed latitudinally as males (Fig 3), but at lower densities, with no mature females caught at most stations in most years, especially in 1998 and 1999. Their distribution pattern was generally similar to that of small males (Fig.2c-d), but in particular to 60-75 mm males (Fig. 2c) in that highest densities shifted from offshore deep and slope areas in 1996 to inshore areas in 1997. Highest densities of mature females in 1999 were located in Div. 3LO, as was true for small males (Fig. 2c-d), but particularly the smallest (Fig. 2d).

Fall survey biomass:

Biomass estimates are interpreted qualitatively because the catchability of the survey trawl for snow crab is unknown, but is known to be less than 1. Estimates for legal-sized males (Table 1) are considered to represent residual (post-fishery) biomass levels, although a small proportion of the annual catch was taken during the October-December survey period in each year.

The precision of biomass estimates for legal-sized males in 1999 was relatively consistent throughout Div. 2J3KLN, with 95% confidence intervals ranging from ±24% of the mean in Div. 3L to ±35% in Div. 2J (Table 1). The Div. 3O estimate was unreliable with confidence intervals ±168% of the mean. Precision was highest for estimates generated for Div. 2J3KLNO overall (±22%). Confidence limits were especially broad for NAFO Div. 3NO in most years, probably due to the highly aggregated distribution in those areas. Biomass estimates for Div. 3NO are not considered to be reliable.

The STRAP residual biomass estimate of Div. 2J3KLNO legal-sized crabs in 1999 (47,140 t) was 45% lower than in 1998 (85,026 t) and approximately similar to the 1995 level (Table 1, Fig. 4). Within Div. 2J3KL, the percentage decrease from 1998 was greater in northern than southern divisions, The biomass index decreased in 1999 by 53% in Div. 2J, by 60% in Div. 3K and by 34% in Div. 3L. Residual biomass peaked progressively later from south to north within Div. 2J3KL; in 1996 in Div. 3L, in 1997 in Div. 3K, and in 1998 in Div. 2J (Table 1, Fig. 4).

Rejection of inshore (Div.3KL) strata from the 1998 data set, for direct comparison to the 1999 fall biomass index which did not include inshore strata, lowers the 1998 biomass index by only 1.5% overall. This resulted in virtually no change in the percentage decline in fall biomass in 1999 in Div. 3KL.

The biomass of mature females across the entire fall survey area has declined regularly since 1995 (Table 2, Fig. 5). While this may imply some concern for egg production, the biomass decline was much sharper in mature females than in largest (legal-sized) males, especially in Div. 3KL (Fig. 5). This suggests no decrease in mating success of females. This is supported by the consistent high proportion of mature females bearing full clutches of viable eggs over the time series (Fig 5).

Projection of Recruitment and Exploitable Biomass:

Projection of biomass based on the 1995-99 fall survey data (Table 3) suggests that the exploitable biomass of legal-sized crabs for 2000 will be about half that of 1999. The 48% decrease in the projected exploitable biomass index was due to a 56% decrease in recruitment, together with the decrease in residual biomass. The contribution due to growth of small-clawed crabs within the residual biomass of legal-sized crabs declined by 54% whereas that due to the standing stock of non-molting large-clawed crabs declined by 45%. Although annual divisional indices are more uncertain than those for the entire survey area, they suggest that the projected decline in exploitable biomass for 2000 will be greater in the northern divisions 3K (59%) and 2J (54%) than in more southern Div. 3L (40%).

The ratio of catch to the exploitable biomass index does not estimate absolute exploitation rate, because catchability of the survey trawl is less than 1, so exploitable biomass is underestimated. However this ratio does indicate that the exploitation rate has been stable during 1997-98, not exceeding 0.40, and increased in 1999, to a maximum of 0.53 (Table 3).

This index of exploitation rate does not account for removals that are not included in the commercial catch. The discard mortality rate has not been quantified but it is probably substantial and would likely increase as biomass declines. Timely application of proper handling and discarding practices would minimize mortality on discarded prerecruit males and soft-shelled legal-sized males as well as small legal-sized males of relatively low commercial value.

Size Composition:

Male size distributions from Div. 2J3KLNO fall surveys reflect the stable commercial (>94 mm) biomass levels during 1996-98 and the decrease in 1999 (Fig. 6). They also reflect a reduced biomass of prerecruits (small-clawed males of 76-94 mm) and hence the reduced recruitment to legal size projected for 2000.

A ‘trough’ evident at about 40-75 mm CW throughout 1996-98 persisted in 1999, perhaps reflecting low catchability of this size group. Such low catchability could be related to size and distribution, especially with respect to substrate type, for this component. For example, catchability of this size group may be low on rough shallow-water strata, where the trawl may not maintain constant contact with the bottom. The reliability of the biomass index for this size group, for indicating future recruitment trends, is unknown.

Abundance of smallest males (<40 mm) continued to decline in 1999 (Fig. 6) as it has throughout the survey time series. This may indicate a series of weak year classes that is expected to provide poor recruitment to the fishery in the longer term. Clearly, this regular decline at such small sizes is not directly related to the fishery. It likely involves a complex interaction of factors that may include bitter crab disease, density-dependent processes, and environmental effects.

Cannibalism on settling year classes has been proposed as a density-dependent mechanism which results in successive weak year classes and an intrinsic oscillation in recruitment (Sainte-Marie et al. 1996, Lovrich and Sainte-Marie 1997, Dawe et al. 1999). However it is unknown how important cannibalism may be as a source of mortality because there are no data on snow crab diet specific to this area.

Alternatively, the regular decline in abundance of smallest crabs may be related to density-independent effects, such as environmental warming (Colbourne 2000). Although cold conditions are believed to be favourable, there is considerable uncertainty regarding effects of warming, since 1995. Environmental variation may affect distribution, behavior, growth, and catchability but it is unclear how it may affect the various life-history stages and subsequently impact recruitment.

The substantial decrease in recruitment projected for 2000 is consistent with the decline in smallest males (<40 mm CW), which has been apparent since 1996, but may have begun earlier. Males of about 40 mm CW are about 4-5 years of age and may begin to recruit to the legal-size group (as new-shelled males) within about four years (Sainte-Marie et al. 1995). The regular decline in abundance of smallest males over the past 4 years suggests that recruitment will continue to deteriorate for at least 4 years before it begins to recover.

Male size frequency distributions were generally similar among divisions within Div. 2J3KL in reflecting the overall decline in abundance for all sizes larger than about 40 mm (Fig. 7). However there was considerable spatial variation in sizes affected and timing of declines for smallest males (Fig. 7). Abundance of Div. 2J small males, of about 23-40 mm in particular, appeared to increase in 1998 and then decline in 1999 approximately to 1996-97 levels, possibly reflecting a change in catchability. In the more southern areas there was a clear regular decline in abundance of small crabs (Fig.7), which occurred later in Div. 3K than in Div. 3L. This decline occurred during 1997-99 in Div. 3K, whereas it began at least one year earlier in Div. 3L. The decline in Div. 3L may have ended in 1998, as suggested by the apparent increase in abundance of small males in 1999.

Distinct modal groups of small males were most prominent in Div. 3L in 1995 and in Div. 3K in 1995-96 (Fig. 7). With these exceptions, modal groups were generally indistinct and their progression through the time series was not apparent. This may indicate high and variable natural mortality rates on small males.

Size distributions for Div. 3NO (Fig. 7) show no clear trends and cannot reliably be interpreted because of the unsuitability of the sampling regime for the highly aggregated resource in this area. However, abundance of small (<40 mm) males, relative to larger males, appears to have declined in Div. 3N and increased in 3O in recent years, consistent with trends in spatial distribution noted earlier.

Bitter Crab Disease:

Bitter Crab Disease (BCD) has been found almost exclusively in new-shelled crabs of both sexes, indicating that it is likely acquired during molting and that it is fatal within a year. Data from 1996-99 fall surveys indicate that the disease occurred in Div.2J3KL in all years and was most prevalent in Div. 3K during 1996-98 (Fig. 8). It has been virtually absent in Div. 3NO in most years. It appears that the spatial distribution of BCD shifted northward during the past 3 years. This apparent shift was especially sharp in 1999, with highest prevalence in Div. 2J and very low frequency in survey catches throughout Div. 3KLNO. However this abrupt change should be considered as preliminary until further data accumulate. This apparent change may be a sampling artifact related to spatial variation in scientific personnel, with various levels of experience in identifying BCD, throughout the survey time series.

Throughout Div. 2J3KL BCD has occurred in all size groups of males and in both immature and mature females (Fig. 9). Infection levels have overall been highest in small males of 40-59 mm CW, with about 8% of that size group infected in Div. 3K during 1996-98. Percent infected was clearly higher in Div. 3K than in Div. 2J or 3L during 1996-98, especially for large males and mature females.

BCD represents a source of natural mortality that could possibly account for the recent decline in abundance of small crabs, especially in Div. 3K, and the failure of modal groups of small crabs to progress in size frequency distributions between successive years. While this seems unlikely, based on the low infection rates observed, it should be recognized that heavily-parasitized crabs may not be representatively sampled by either traps or trawl. Furthermore, molting is frequent at small sizes (Sainte-Marie et al. 1995) and the disease is likely acquired at molting, so the cumulative effect of this mortality across successive instars of a yearclass may be substantial.

NAFO Div. 3K Inshore Sampling

September small-meshed trap catch rates of intermediate-sized males (about 40-75 mm CW) decreased in 1999 in all three depth strata of White Bay (Fig. 10). This decrease was most pronounced in the shallower strata where it followed a regular increase throughout 1995-98 (Dawe et al. 1999). This supports the view that the consistent ‘trough’ seen in size compositions of trawled samples, at about 40-75 mm CW, reflects inadequate sampling. Sampling of this size group may be inadequate due to an aggregated distribution (e.g. in inshore areas) and quite possibly low catchability of the trawl especially on hard, shallow-water substrates.

It has been shown from comparative sampling with small-meshed traps and the Campelen trawl in September 1998 that trap and trawl catch rates were similar in the deepest stratum but higher for traps, by a factor of 10, in the shallowest strata (Dawe et al. 1999). The size composition of trawl-caught males in the two shallow White Bay strata in both 1998 and 1999 (Fig.11) was similar to that from small-meshed traps, being comprised mostly of intermediate-sized (40-75 mm) males which were poorly-represented in the fall bottom trawl surveys throughout Div. 2J3KLNO, and in Div. 3K in particular. Trawl-caught males were generally larger in Notre Dame Bay than in White Bay, for comparable depth strata (Fig. 11).

The great increase in trap catch rates of such intermediate-sized crabs in White Bay during 1996-98 suggests competitive displacement from preferred substrates in deeper strata by larger crabs. Decrease in trap catch rates in 1999 may reflect expansion to preferred deeper strata, consistent with the decrease in fall bottom trawl survey biomass of larger crabs. The increase in catch rates of intermediate-sized males in White Bay in 1999 with the trawl (Fig. 11), concurrent with a decrease in their catch rate with small-meshed traps (Fig. 10), could be accounted for by an increase in their catchability by the trawl, possibly due to a change in distribution.

Inshore Div. 3K trap surveys during September have approximately corresponded with the peak season of incidence of BCD in Alaskan tanner crab (*Chionecetes bairdi*) (Love et al. 1993). These surveys indicate that in White Bay incidence of BCD has increased overall since 1995, and it appears to have progressed to deeper strata and larger males (Fig. 12). No such clear trends were evident in Notre Dame Bay during 1997-99. In both White Bay and Notre Dame Bay incidence of BCD increased, and became most prevalent, in smallest males (<60 mm) in 1999.

NAFO Div. 3Ps Spring Bottom Trawl Surveys

Spatial distribution patterns appeared to be similar among all size groups of males (Fig. 13) and mature females (Fig 14). For all those population components most survey catches and highest densities occurred in the deep northeastern portion of Div. 3Ps. Few and small catches occurred on the shallow banks or in the deep channels in outer western and southern portions of Div. 3Ps, especially in 1997 and 1999. This was particularly evident in smallest males (Fig. 13d).

Biomass estimates of legal-sized males for NAFO Div. 3Ps from spring pre-fishery surveys during 1996-99 are highly unreliable, as indicated by broad confidence intervals, especially in 1999 (±79%, Table 4). Such poor estimates are probably largely due to the highly aggregated biomass, as also noted for Div. 3NO from the fall surveys. The spring biomass index of legal-sized crabs for 1997 was lower than both the 1996 biomass estimate and the 1997 catch by a factor of 4 (Dawe et al. 1999). It almost doubled in 1998, and further increased by 19% in 1999, but remained unrealistically low. Such low estimates probably reflect lower catchability in spring than fall, associated with distribution and behavior patterns during the spring molting season.

Because of inadequate sampling by the spring surveys, it is not possible to infer recruitment trends from size composition. Small-clawed males were very poorly represented within the larger size groups in all years (Fig. 15), supporting the belief that their catchability is low during the molting season. However spring size frequencies (Fig. 15) show that a ‘trough’ at about 40-70 mm CW remained stationary throughout 1996-99, as noted from the fall Div. 2J3KLNO surveys. This supports the suggestion of low catchability of this size group by the survey trawl. There was no clear increase or decline in abundance of smallest males (<40 mm) relative to largest males over the time series.

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Table 1. Minimum trawlable biomass estimates for legal-sized males from the 1995-99 fall Div. 2J3KLNO mulitspecies bottom trawl surveys, with 95% confidence intervals and mean catch rates, by NAFO Division and for the entire survey area.

NAFO Div.	Year	Biomass T	Confidence Intervals	Mean Kg/set
2J	1995	4,267	± 37%	1.4
	1996	7,291	± 36%	2.03
	1997	11,741	± 54%	3.17
	1998	14,579	± 43%	3.93
	1999	6,835	± 35%	1.84
3K	1995	12,692	± 24%	2.4
	1996	22,971	± 19%	4.23
	1997	27,736	± 31%	4.37
	1998	22,180	± 23%	4.08
	1999	8,950	± 31%	1.80
3L	1995	27,457	± 31%	4.5
	1996	36,015	± 35%	5.31
	1997	29,002	± 32%	4.27
	1998	29,538	± 23%	4.34
	1999	16,756	± 24%	2.66
3N	1995	2,222	± 60%	0.8
	1996	8,312	± 74%	3.25
	1997	6,120	± 372%	2.39
	1998	13,596	± 74%	5.26
	1999	8,076	± 32%	3.15
3O	1995	4,494	± 121%	1.6
	1996	1,362	± 514%	0.78
	1997	1,917	108%	1.10
	1998	5,132	± 76%	1.89
	1999	6,523	± 168%	2.40
2J3KLNO Total	1995	51,132	± 20%	2.71
	1996	75,951	± 14%	3.79
	1997	76,516	± 15%	3.51
	1998	85,026	± 14%	4.05
	1999	47,140	± 22%	2.36

Table 2. Minimum trawlable biomass estimates for mature females from the 1995-99 fall Div. 2J3KLNO multispecies bottom trawl surveys, with 95% confidence intervals and mean catch rates, by NAFO Division and for the entire survey area.

NAFO Div.	Year	Biomass T	Confidence Intervals	Mean kg/set
2J	1995	90	± 105%	0.03
	1996	92	± 58%	0.03
	1997	149	± 407%	0.04
	1998	199	± 74%	0.05
	1999	55	± 78%	0.01
3K	1995	2,750	± 45%	0.56
	1996	1,311	± 71%	0.24
	1997	633	± 47%	0.12
	1998	273	± 33%	0.05
	1999	102	± 64%	0.02
3L	1995	3,825	± 38%	0.63
	1996	2,500	± 83%	0.37
	1997	879	± 25%	0.13
	1998	319	± 45%	0.05
	1999	499	± 55%	0.08
3N	1995	206	± 465%	0.08
	1996	375	± 61%	0.15
	1997	44	± 91%	0.02
	1998	93	± 955%	0.04
	1999	170	± 585%	0.07
3O	1995	215	± 63%	0.07
	1996	68	± 1034%	0.04
	1997	100	± 151%	0.06
	1998	146	± 227%	0.05
	1999	172	± 59%	0.06
2J3KLNO Total	1995	7,086	± 26%	0.36
	1996	4,346	± 43%	0.22
	1997	1,805	± 17%	0.1
	1998	1,030	± 35%	0.05
	1999	998	± 34%	0.05

Table 3. Projection of exploitable biomass indices of legal-size crabs from 1995-99 fall Div. 2J3KLNO surveys.

Year projected	Residual legal-sized (t) Standing Stock Large-clawed[1]	Residual legal-sized (t) Growth Small-clawed[2]	Recruitment[3] (t)	Projected Exploitable Biomass (t)	Catch (t)	Catch: Exploitable Biomass Index
1996	50,588	6,286	19,799	76,673	34,122	0.45
1997	61,688	12162	26,876	100,726	40,181	0.40
1998	66,845	20,036	24,470	111,351	44,382	0.40
1999	75,226	16,372	21,051	112,650	59,643	0.53
2000	41,690	7,558	9,167	58,415		

[1] Large-clawed legal-sized crabs do not subsequently molt and so Would be intermediate-shelled or old-shelled and fully available to the fishery throughout the subsequent (projected) year.

[2] Small-clawed legal-sized crabs molt and grow (by about 19 mm CW) but remain new-shelled and generally unavailable to the fishery until fall of the subsequent year.

[3] Small-clawed prerecruit crabs of 76-94 mm CW molt, grow (by about 19 mm CW) and recruit to legal size in the subsequent year but would remain new-shelled and generally unavailable to the fishery until fall of that year.

Table 4. Minimum trawlable biomass estimates of legal-sized males, with 95% confidence intervals and mean catch rates, from the 1996-99 spring bottom trawl surveys in NAFO Div. 3Ps.

Year	Biomass t	Confidence Intervals	Mean Kg/set
1996	5,397	± 66%	2.33
1997	1,246	± 49%	0.45
1998	2,190	± 46%	0.76
1999	2,607	± 79%	0.99

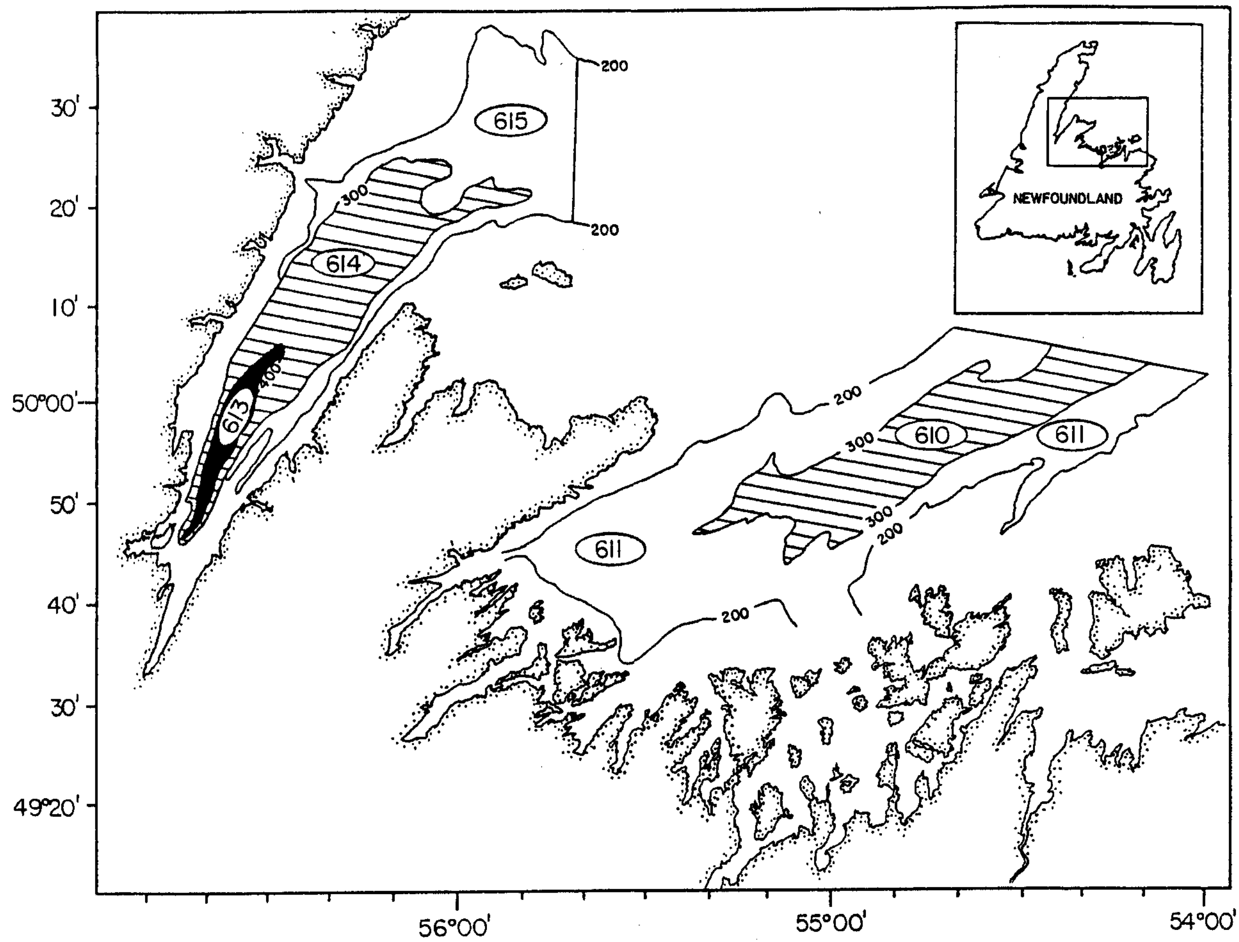


Figure 1. Inshore NAFO Div. 3K strata sampled during 1994-1999 trap surveys in White Bay and Notre Dame Bay.

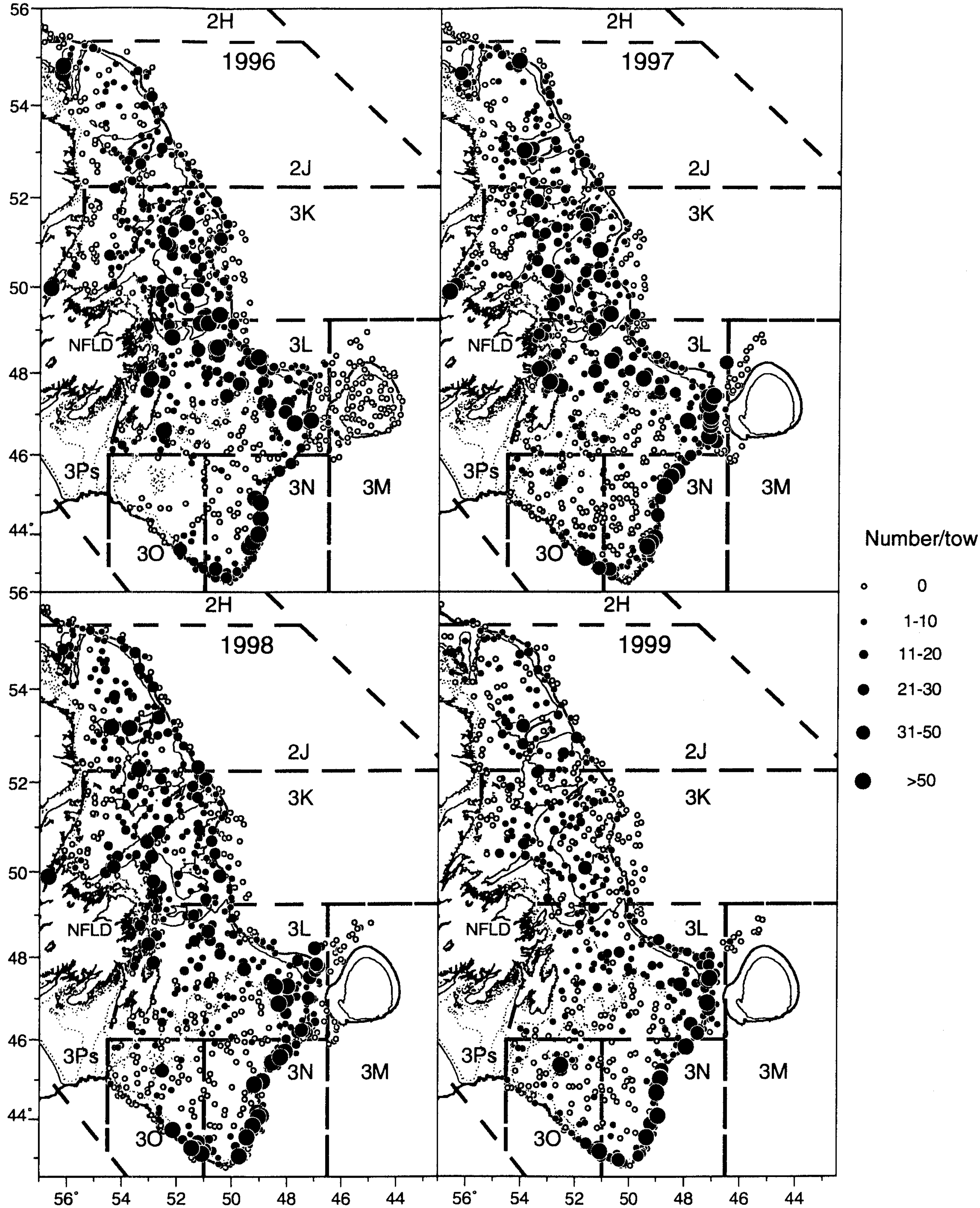


Figure 2a. Distribution of legal-sized males (>94 mm.) from fall 2J3KLNO Campelen surveys, 1996-1999.

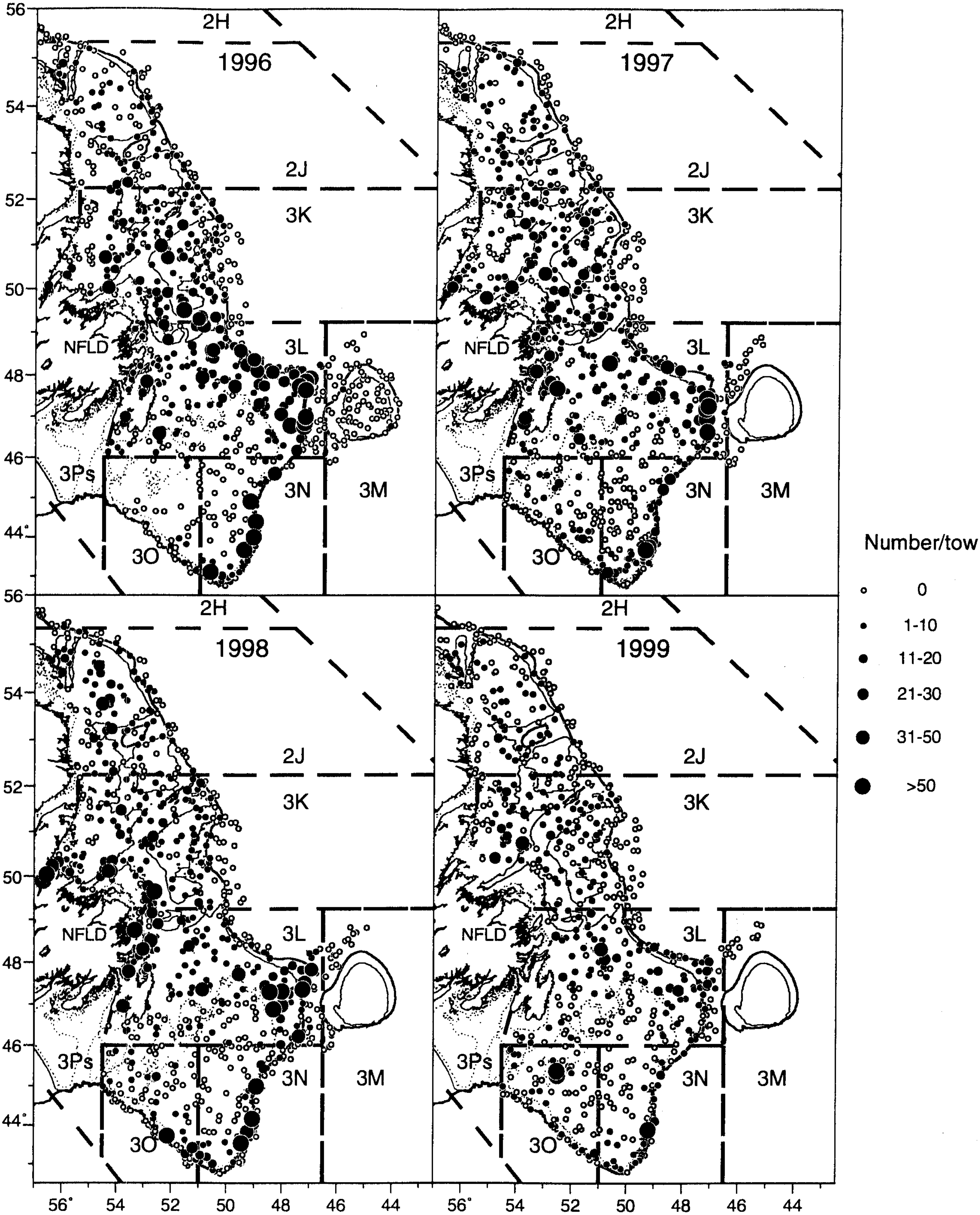


Figure 2b. Distribution of sub-legal 1 males (76-94 mm.) from fall 2J3KLNO Campelen surveys, 1996-1999.

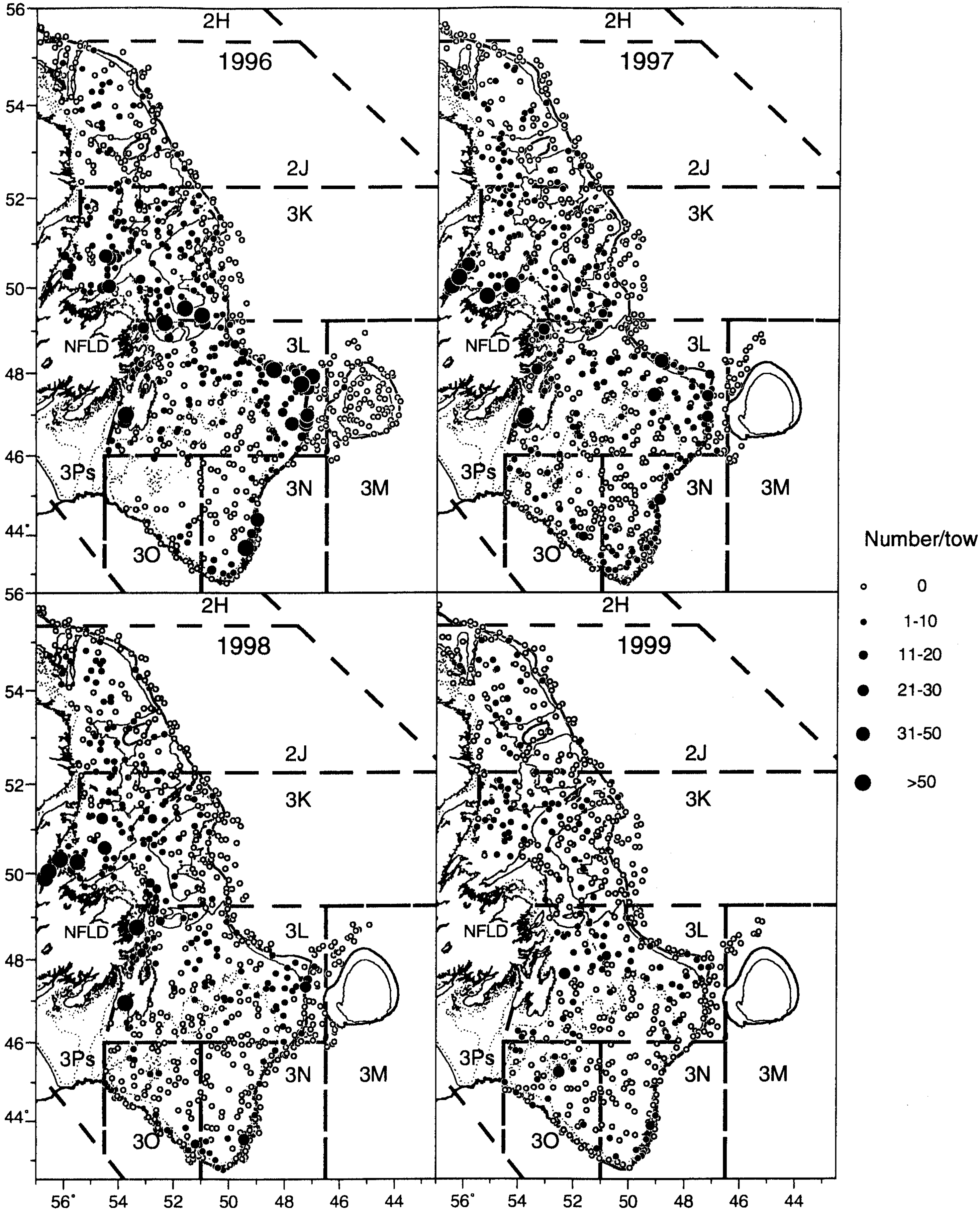


Figure 2c. Distribution of sub-legal 2 males (60-75 mm.) from fall 2J3KLNO Campelen surveys, 1996-1999.

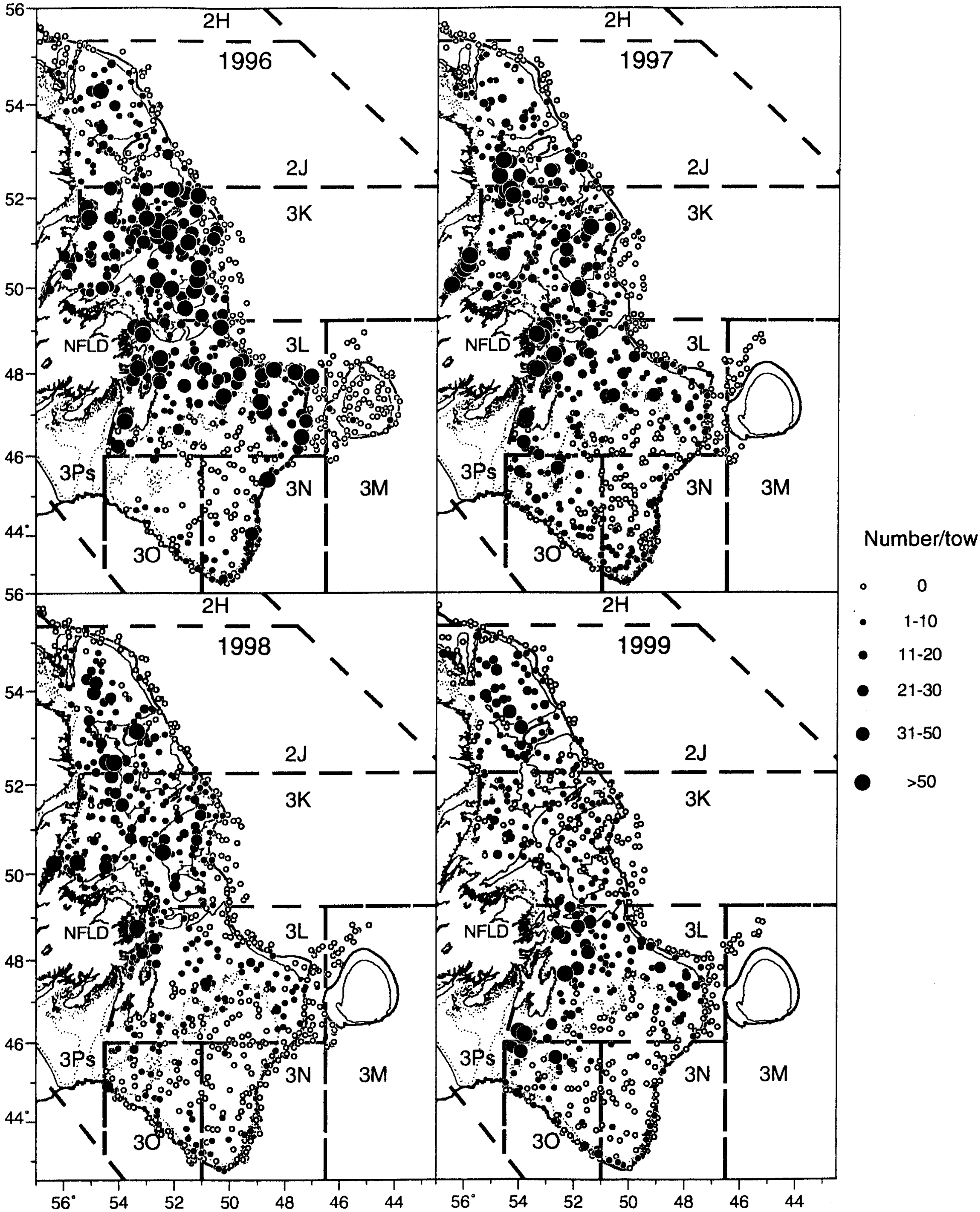


Figure 2d. Distribution of smallest males (<60 mm.) from fall 2J3KLNO Campelen surveys, 1996-1999.

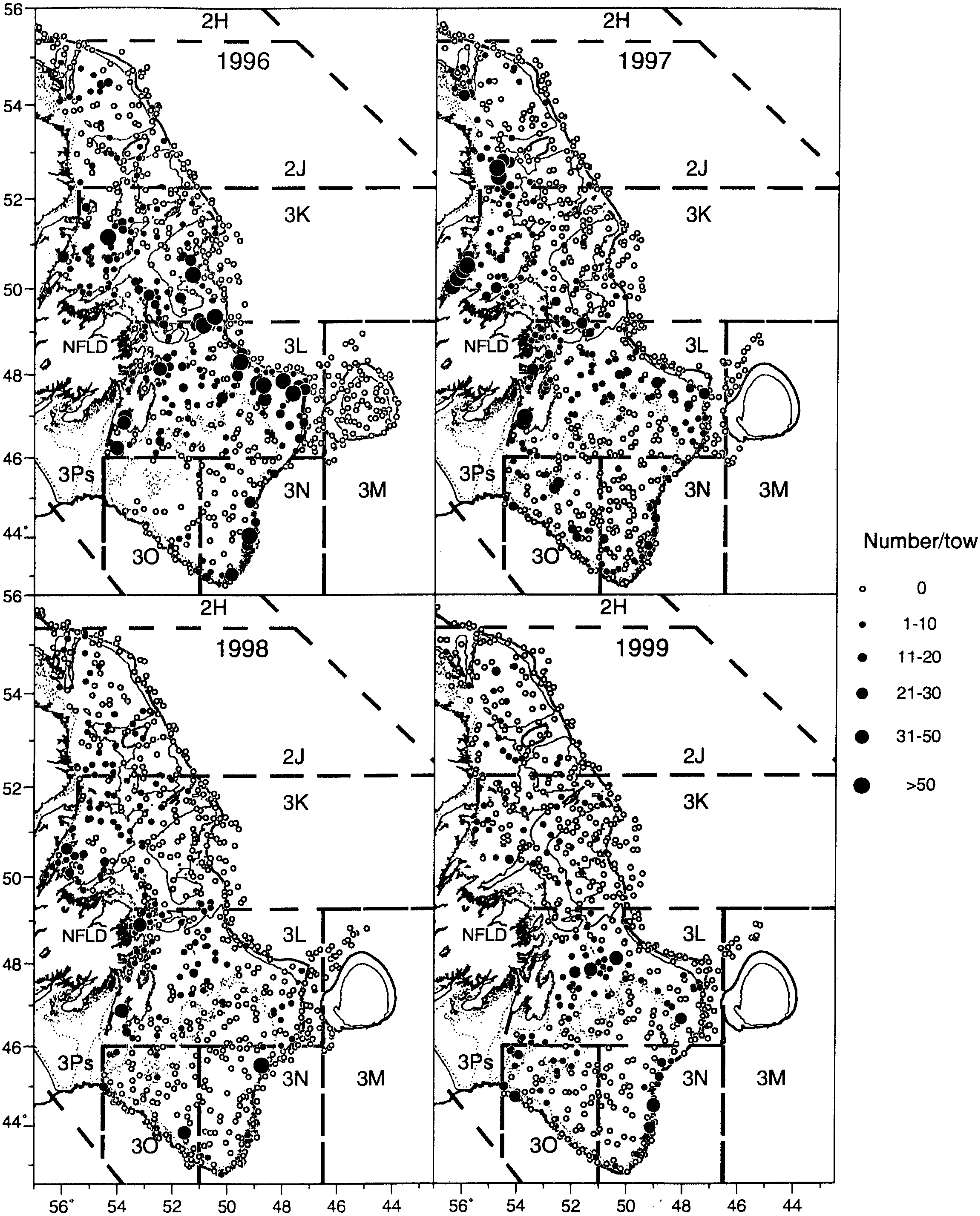


Figure 3. Distribution of mature females from fall 2J3KLNO Campelen surveys, 1996-1999.

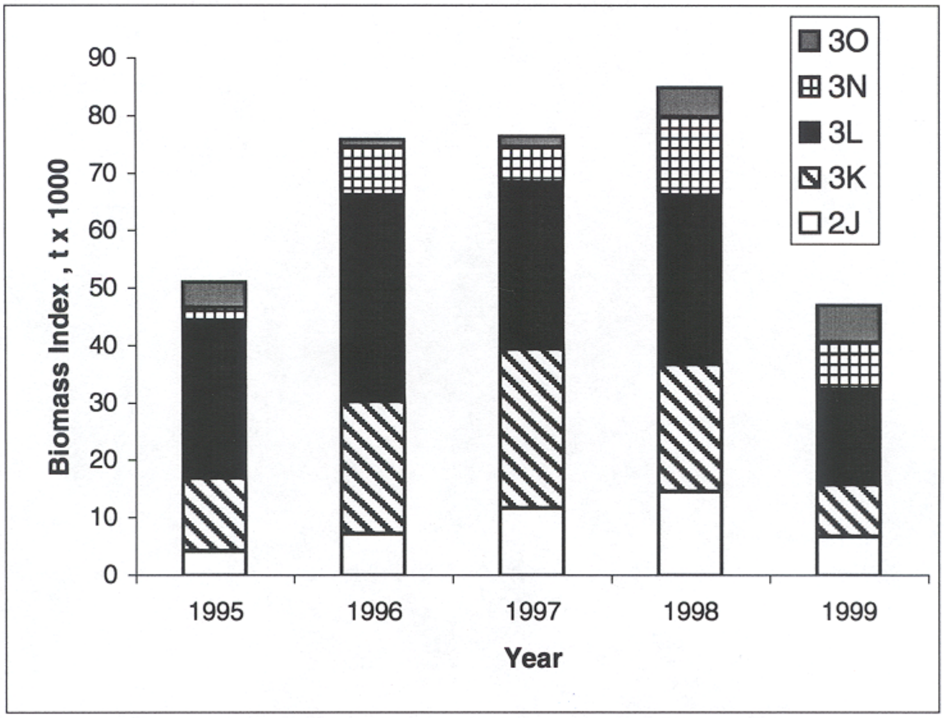


Figure 4. Minimum trawlable biomass estimates by NAFO Division and year from 1995-99 fall Div. 2J3KLNO multispecies bottom trawl surveys.

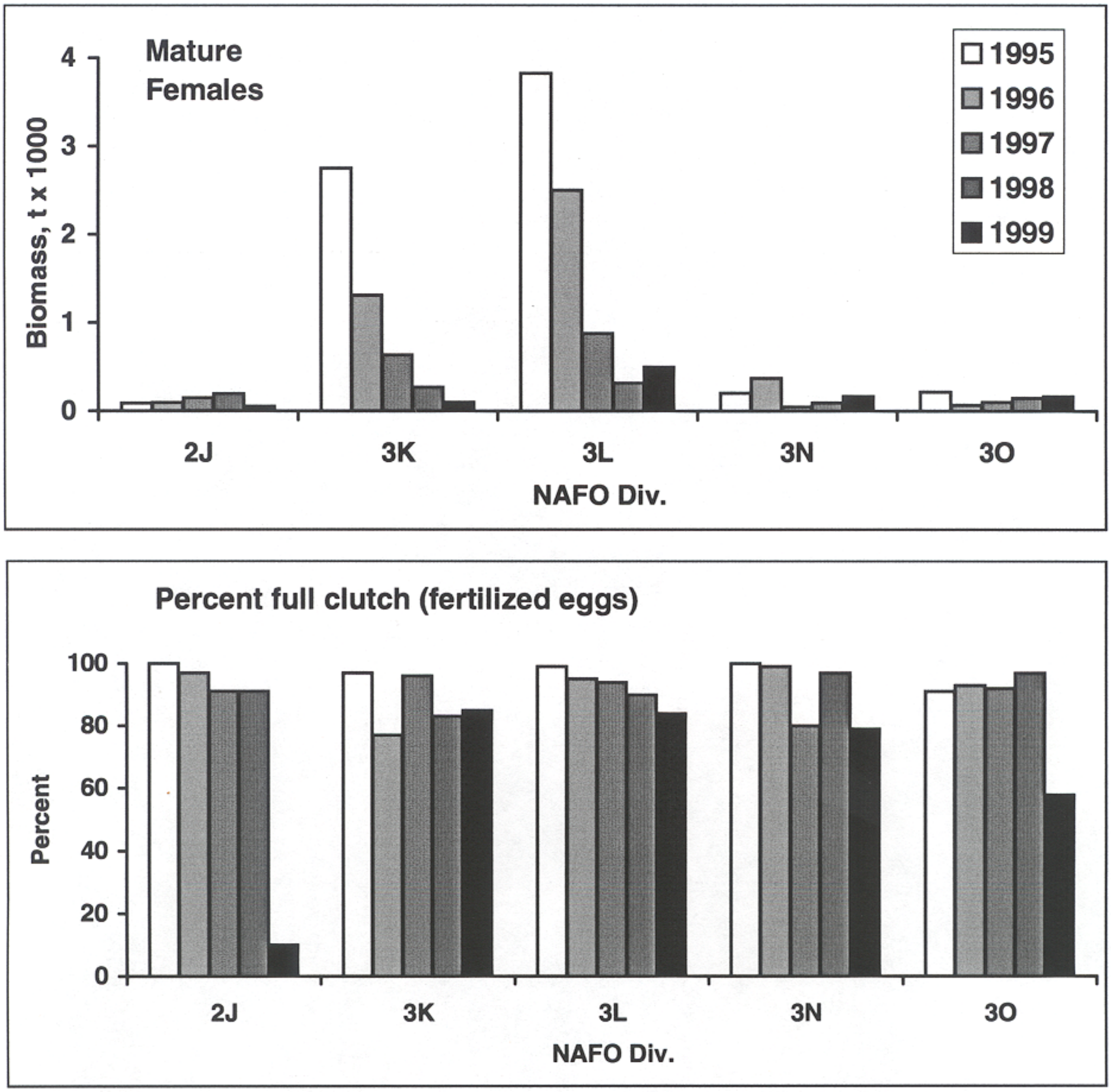


Figure 5. Annual trends in biomass of mature females and in percent of mature females bearing full clutches of viable eggs, by NAFO Division, from fall Div. 2J3KLNO multispecies surveys.

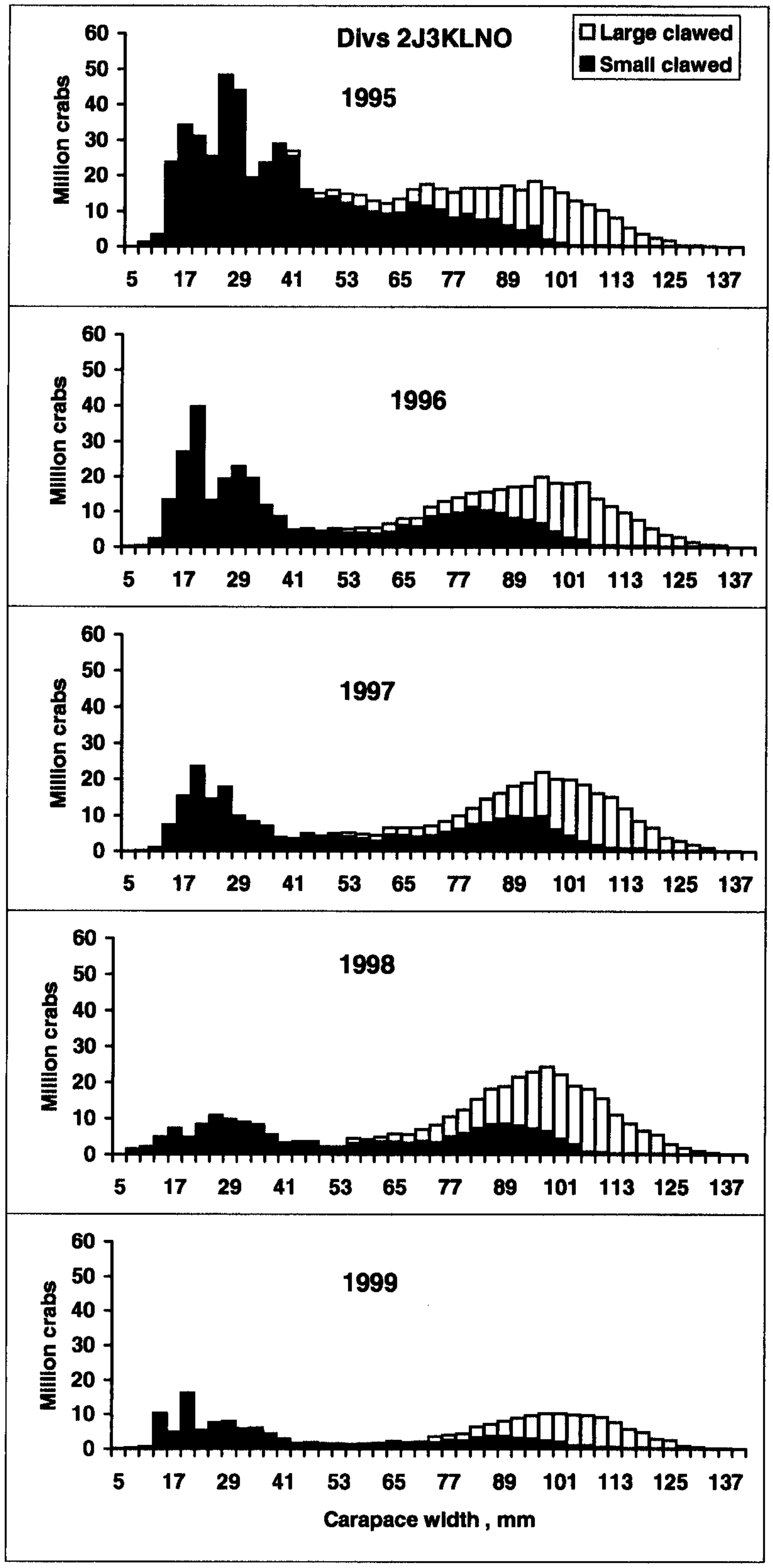


Figure 6. Male size distributions from Div. 2J3KLNO fall multispecies surveys by year and claw typ

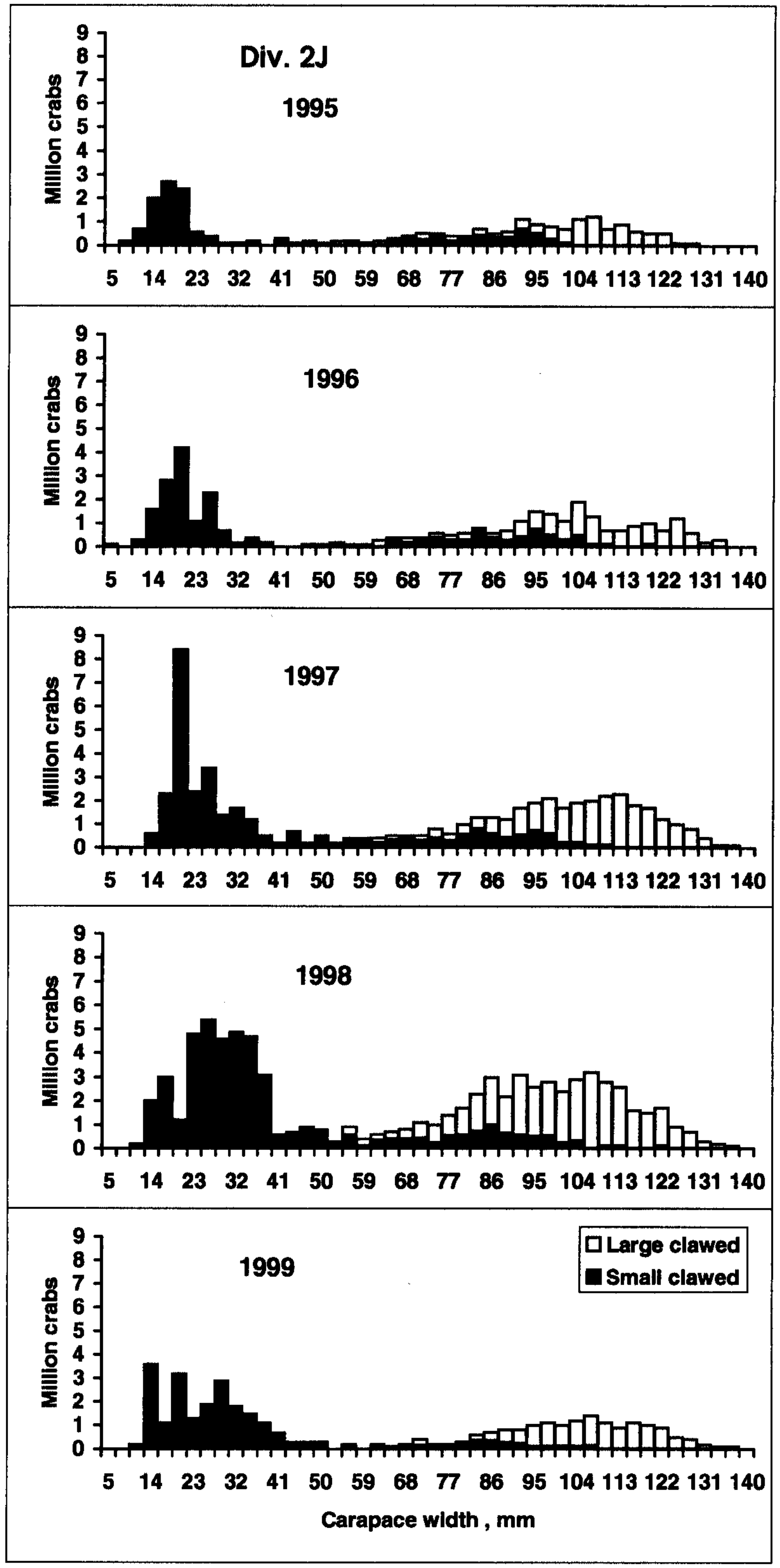
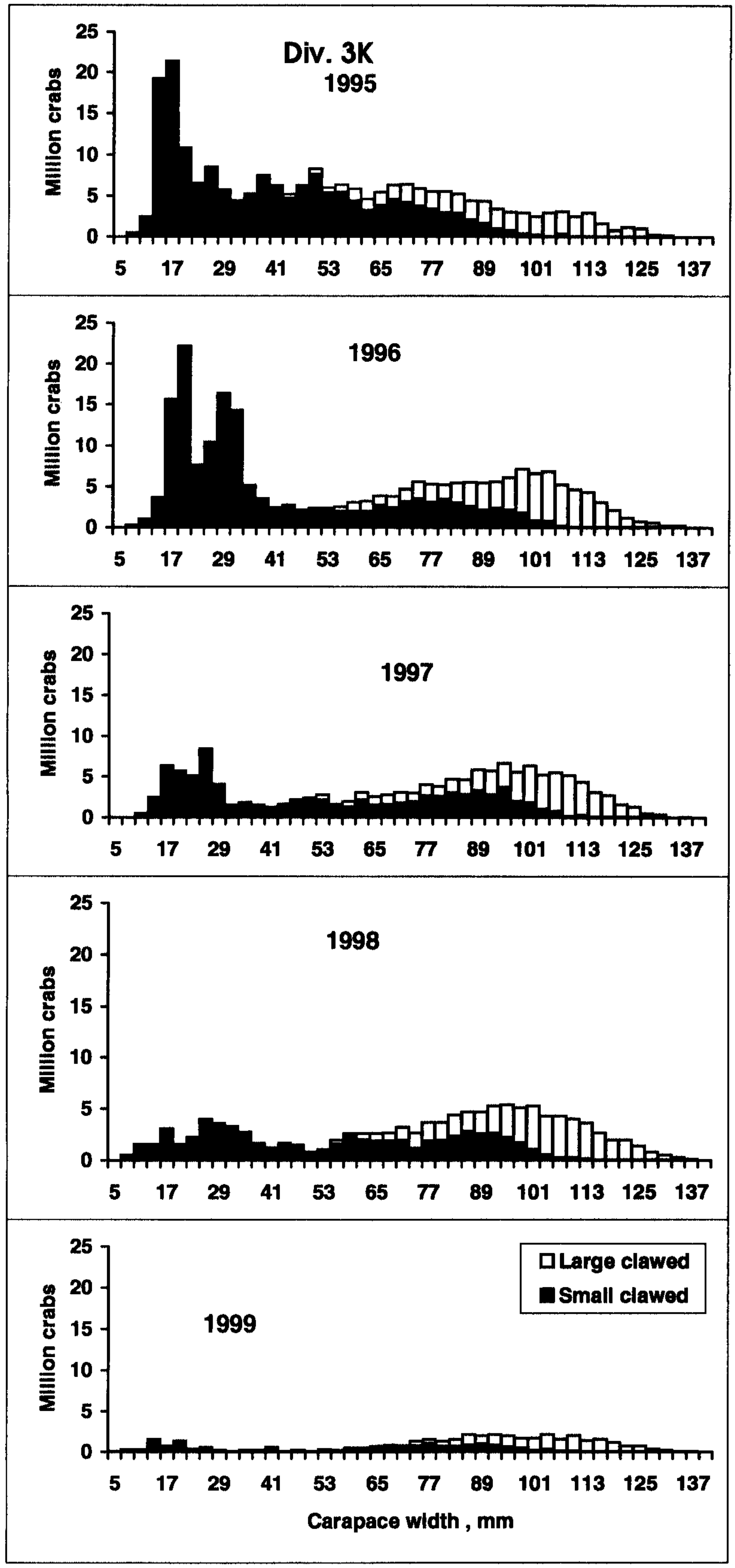


Figure 7. Male size distributions by year and claw type for each division from fall Div. 2J3KLNO multispecies surveys



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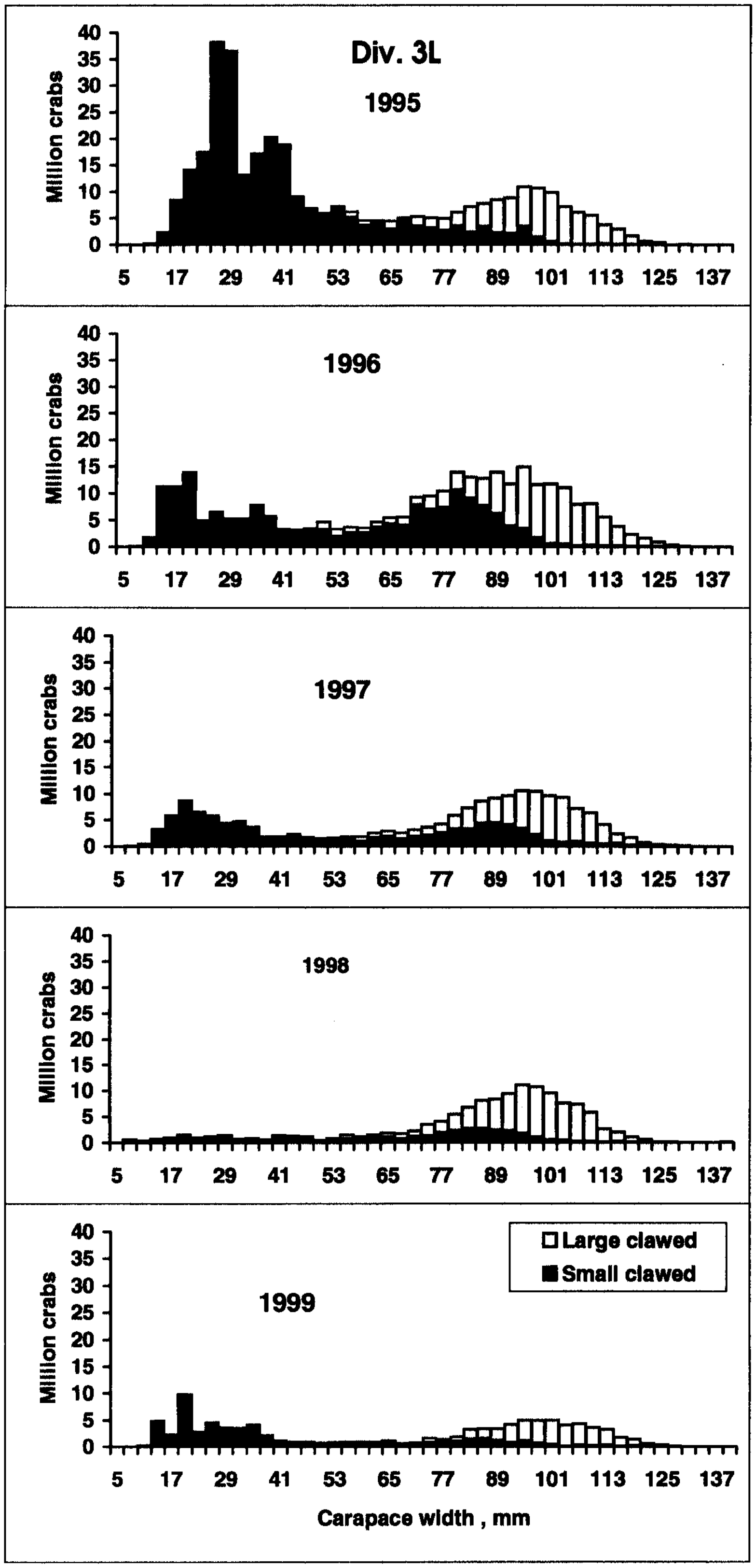

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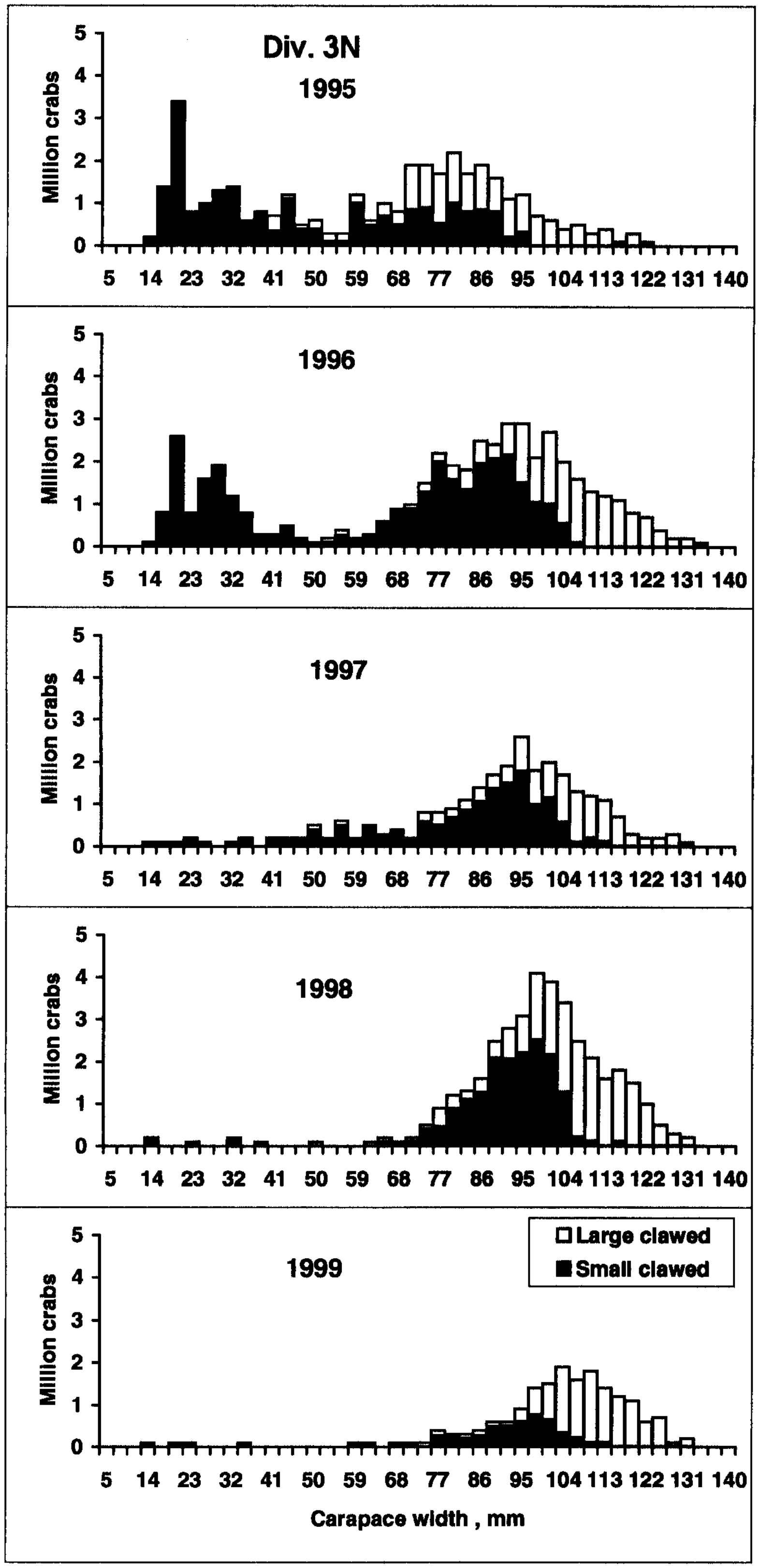

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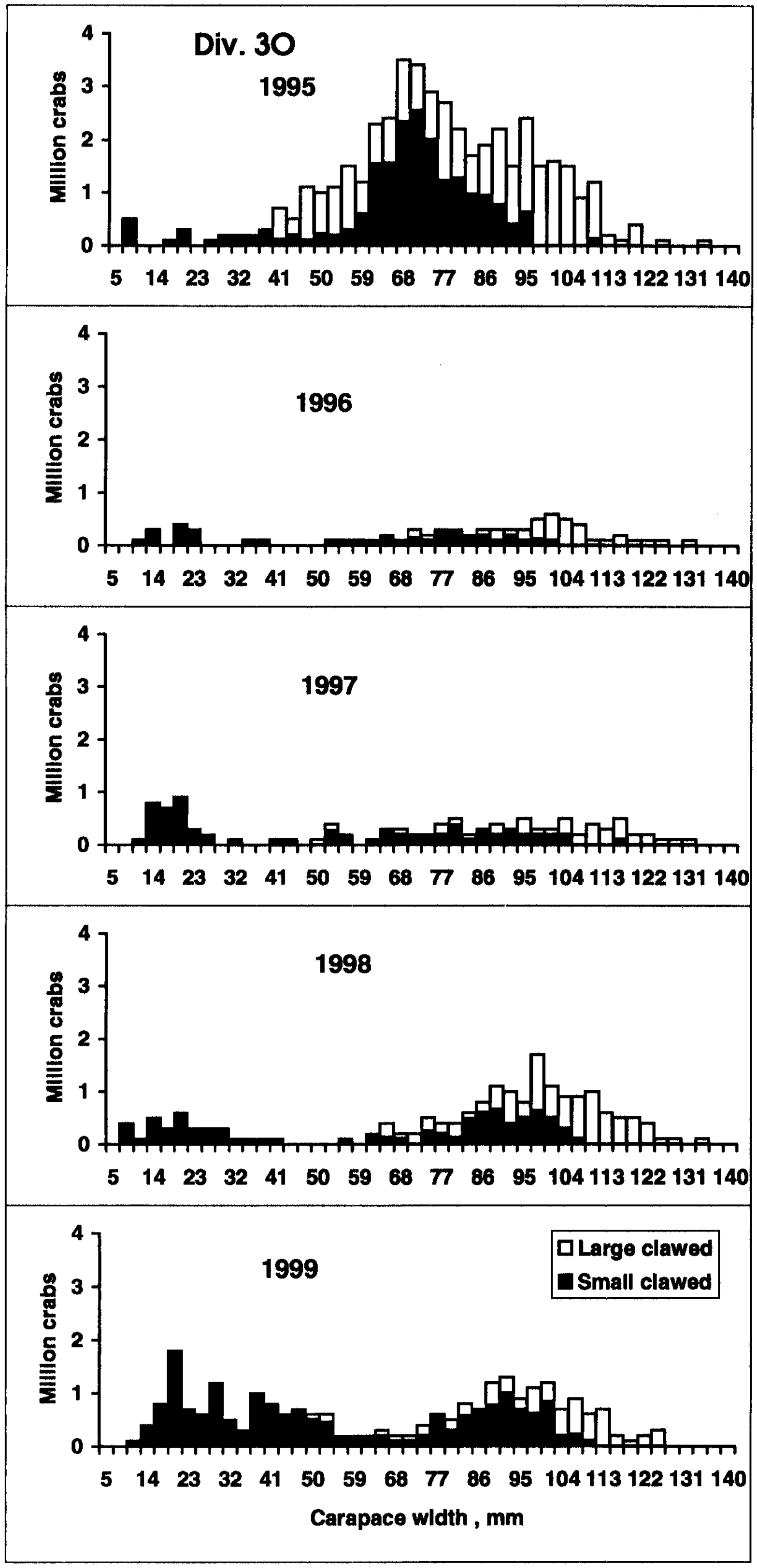

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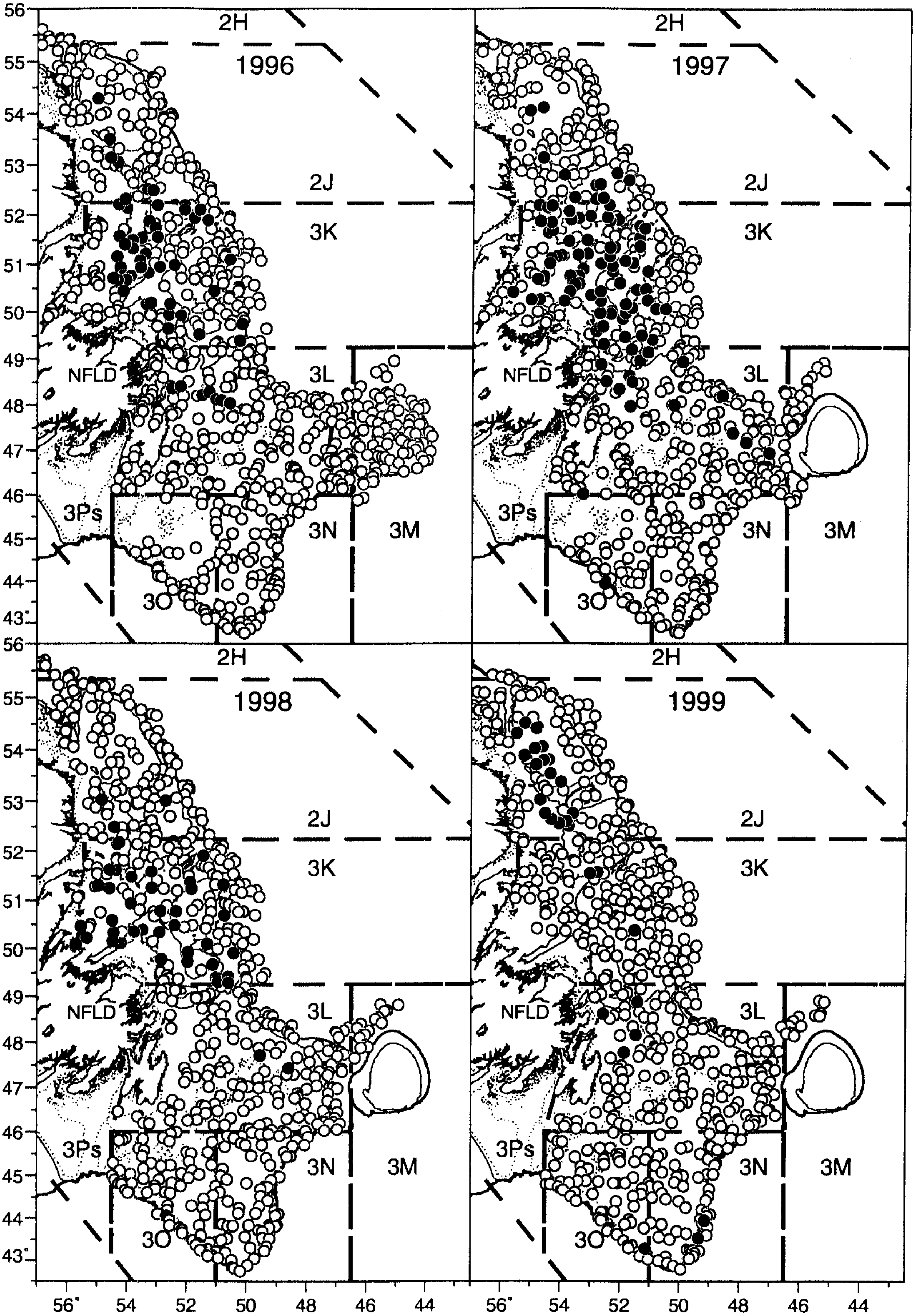

Figure 8. Distribution of sets in which BCD was observed in males (closed circles) versus sets in which no males were caught or BCD was not observed (open circles), from 1996-1999 fall multispecies surveys.

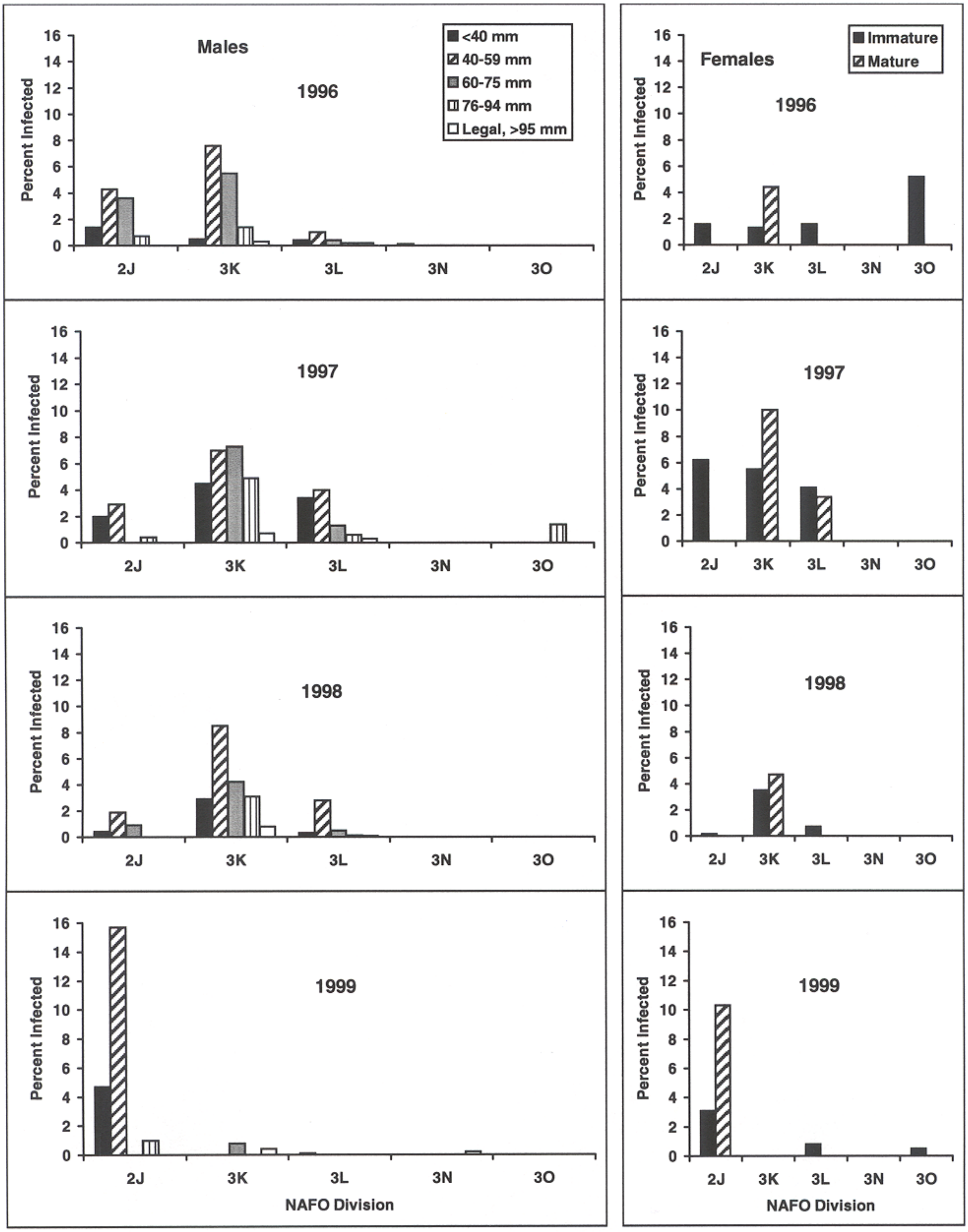

Figure 9. Incidence of BCD from fall Div. 2J3KLNO multispecies surveys by sex, year, division, size (for males) and maturity (for females).

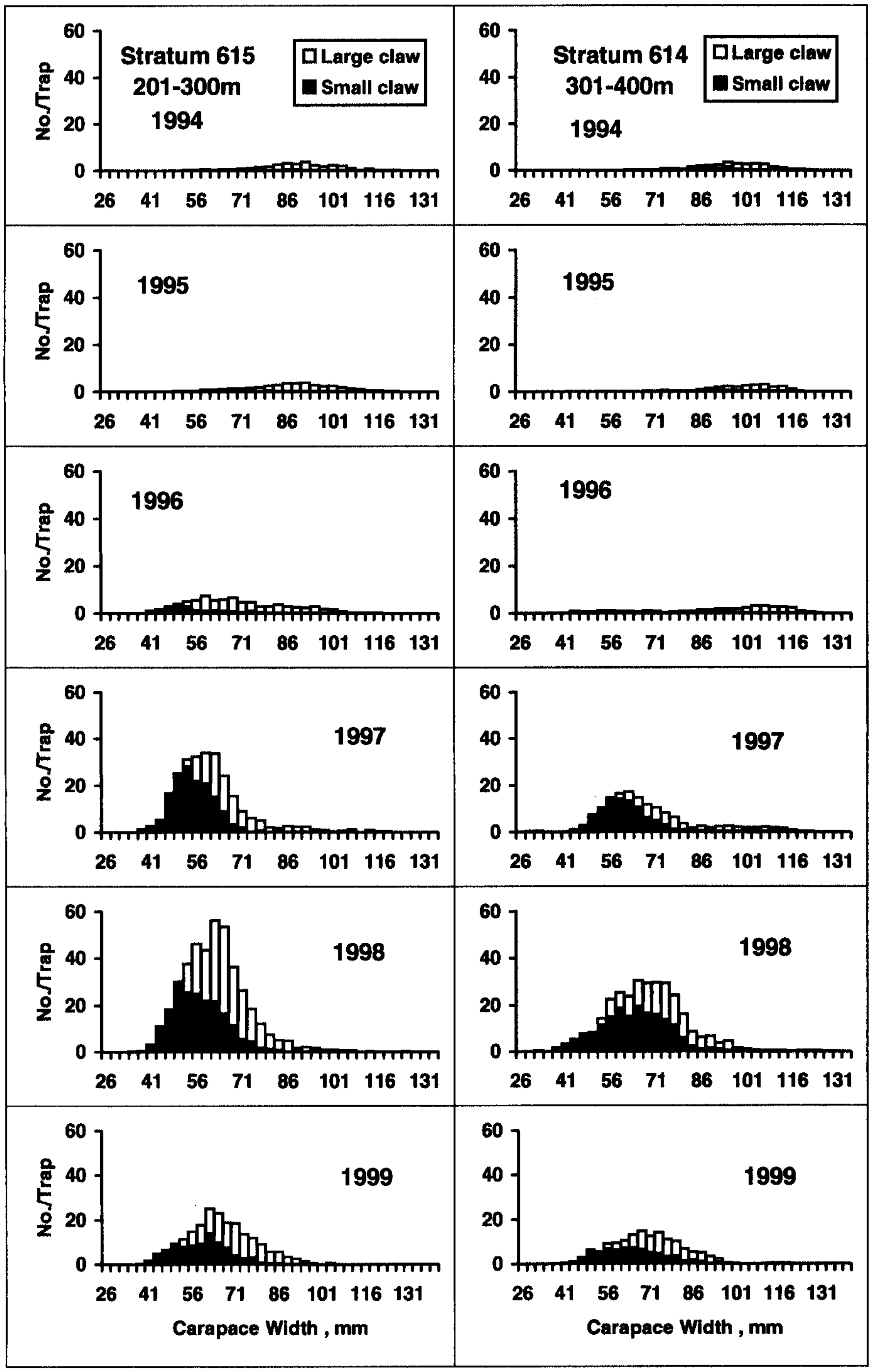

Figure 10. Male size distributions from small-meshed traps by year for each of three White Bay depth strata.

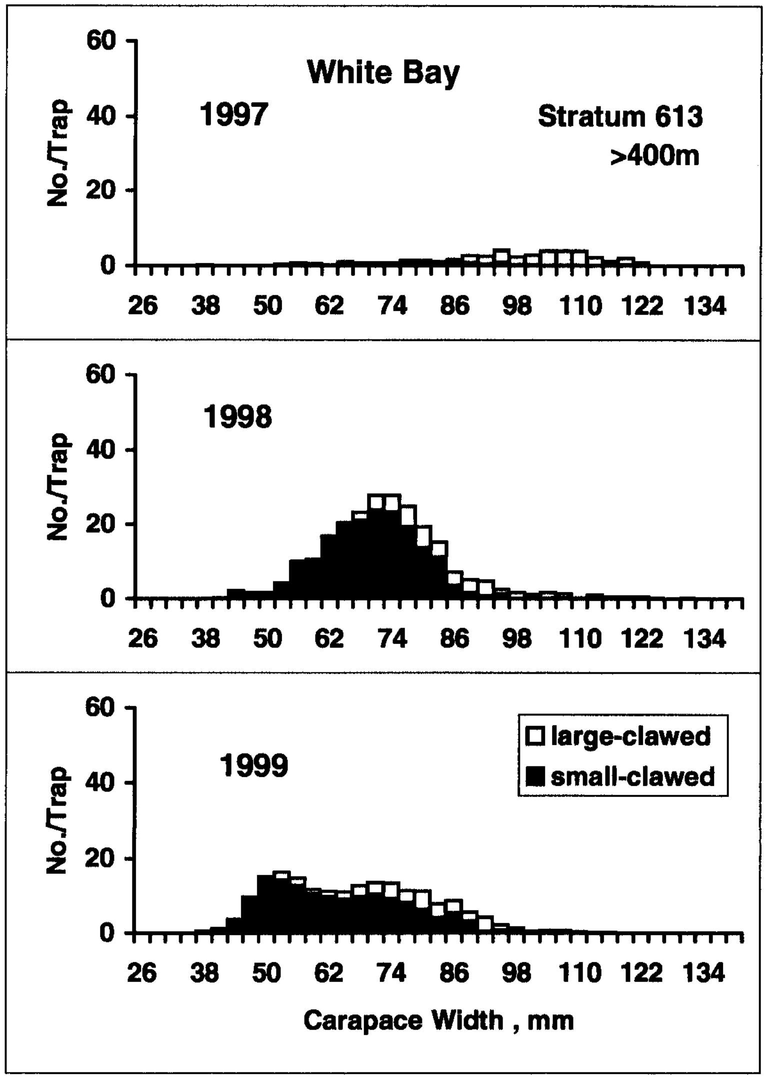

Figure 10. Continued.

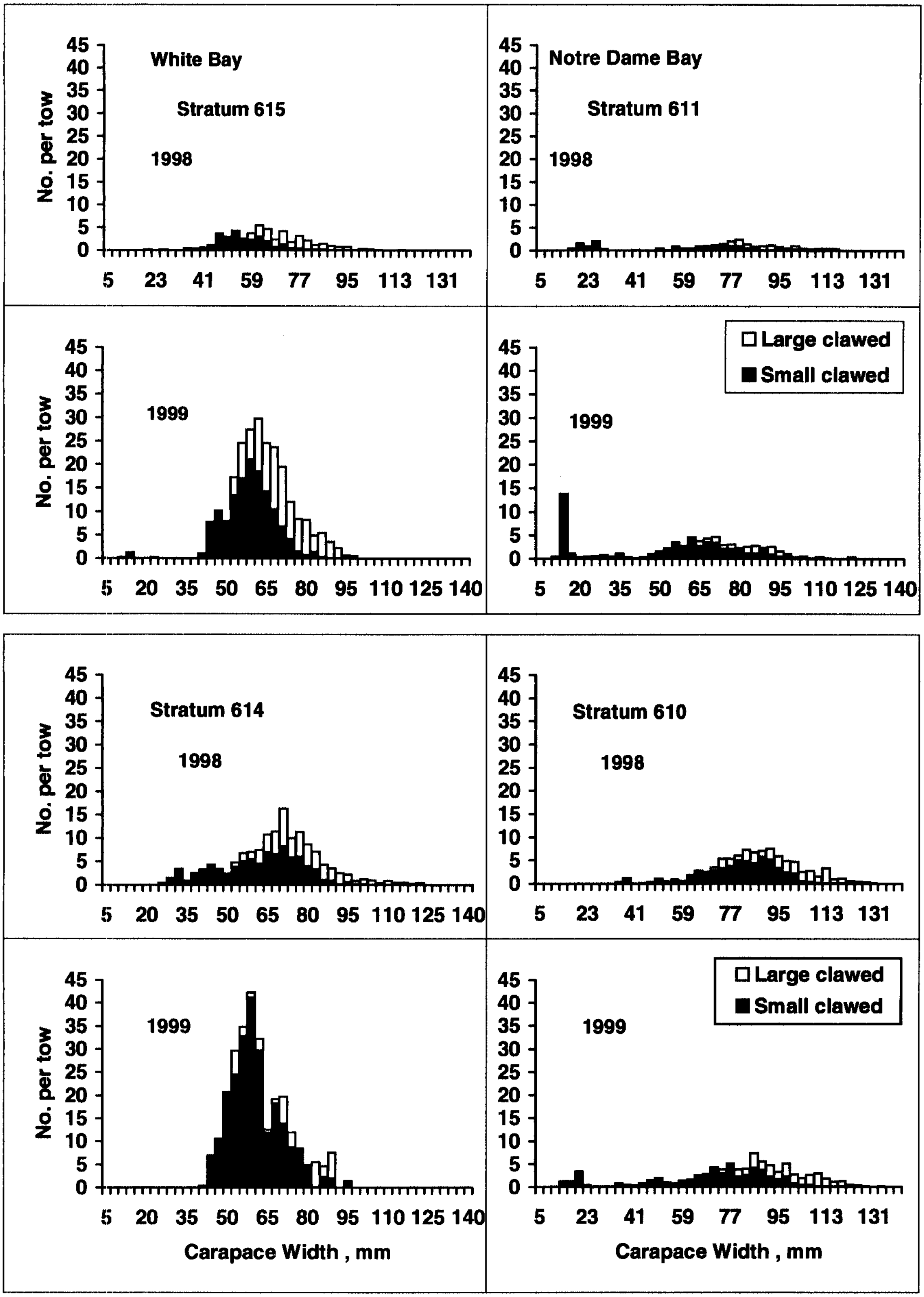

Figure 11. Male size distributions from September 1998-99 Campelen trawl sets in White Bay and Notre Dame Bay, by year, stratum, and claw type.

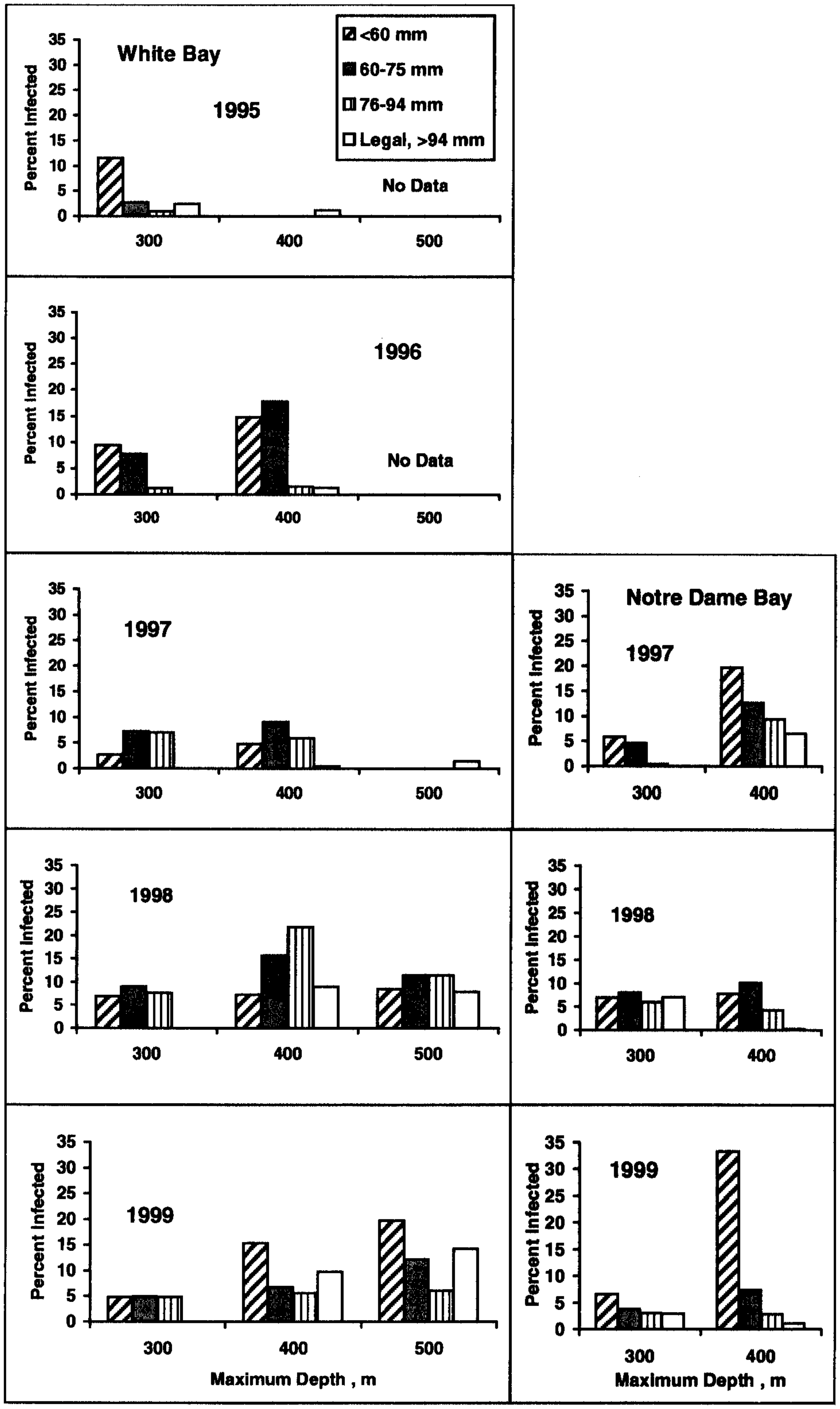

Figure 12. Incidence of BCD by year, male size group, and stratum from small-meshed traps during September in White Bay and Notre Dame Bay.

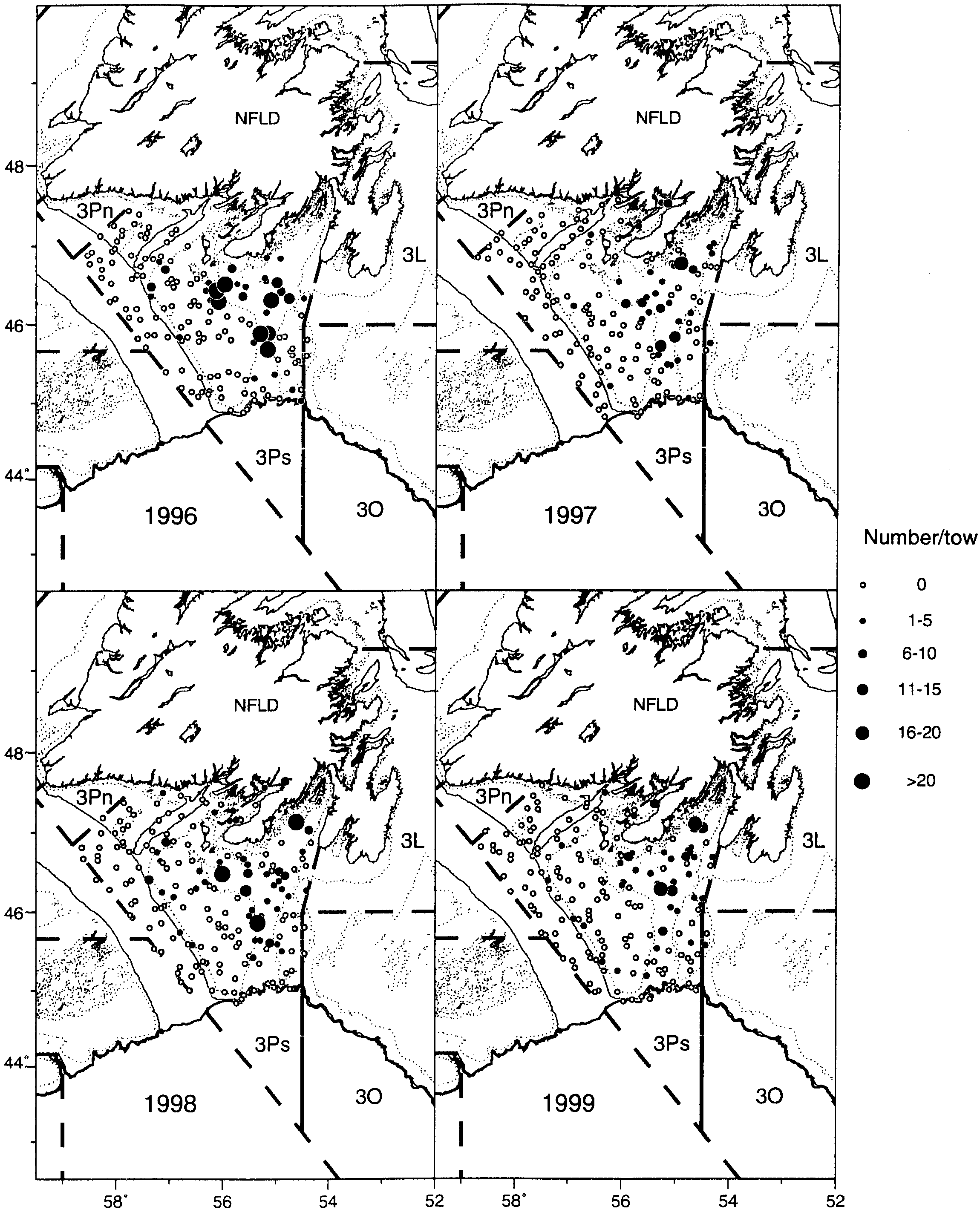

Figure 13a. Distribution of legal-sized males (>94 mm.) from spring 3P Campelen surveys, 1996-1999.

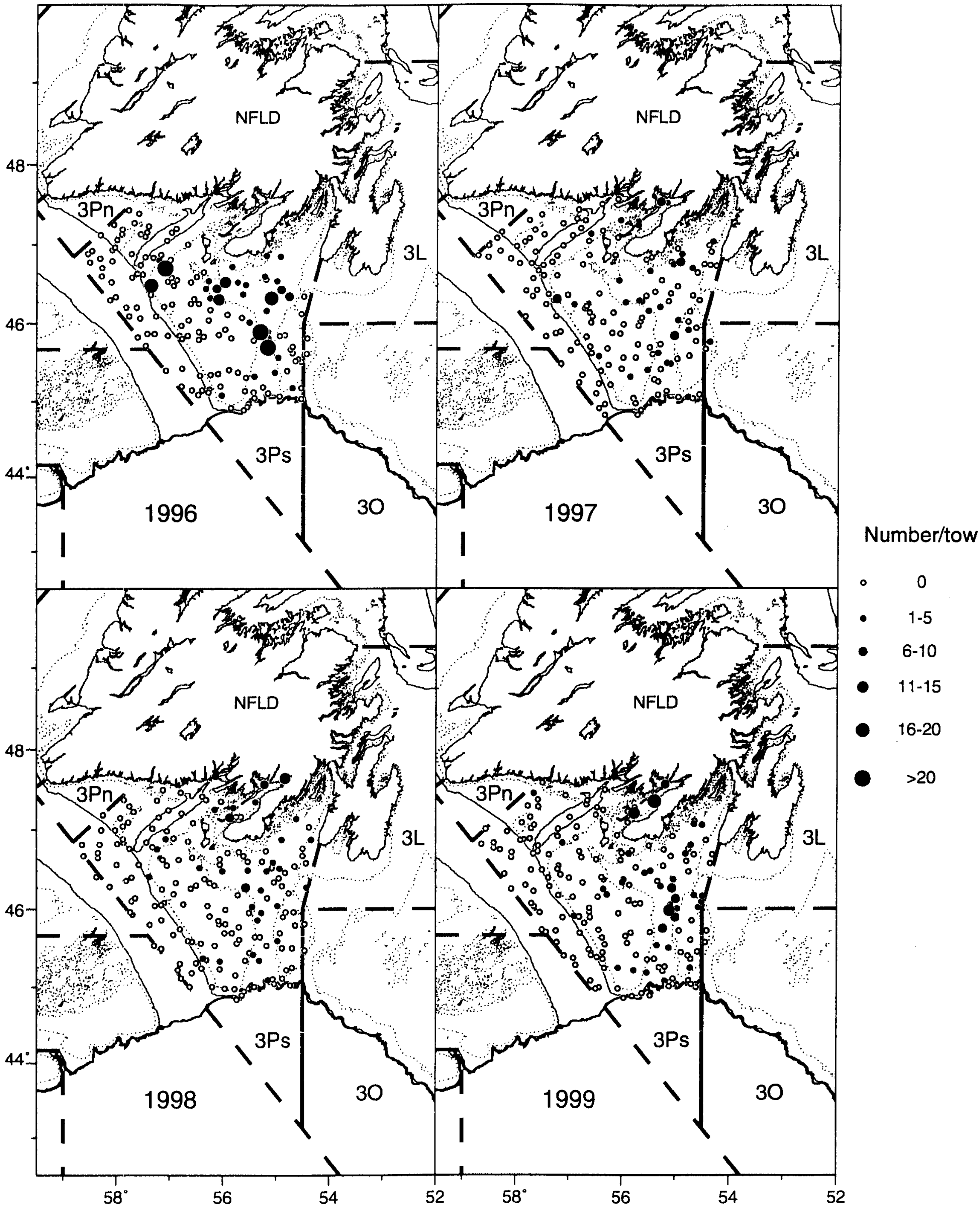

Figure 13b. Distribution of sub-legal 1 males (76-94 mm.) from spring 3P Campelen surveys, 1996-1999.

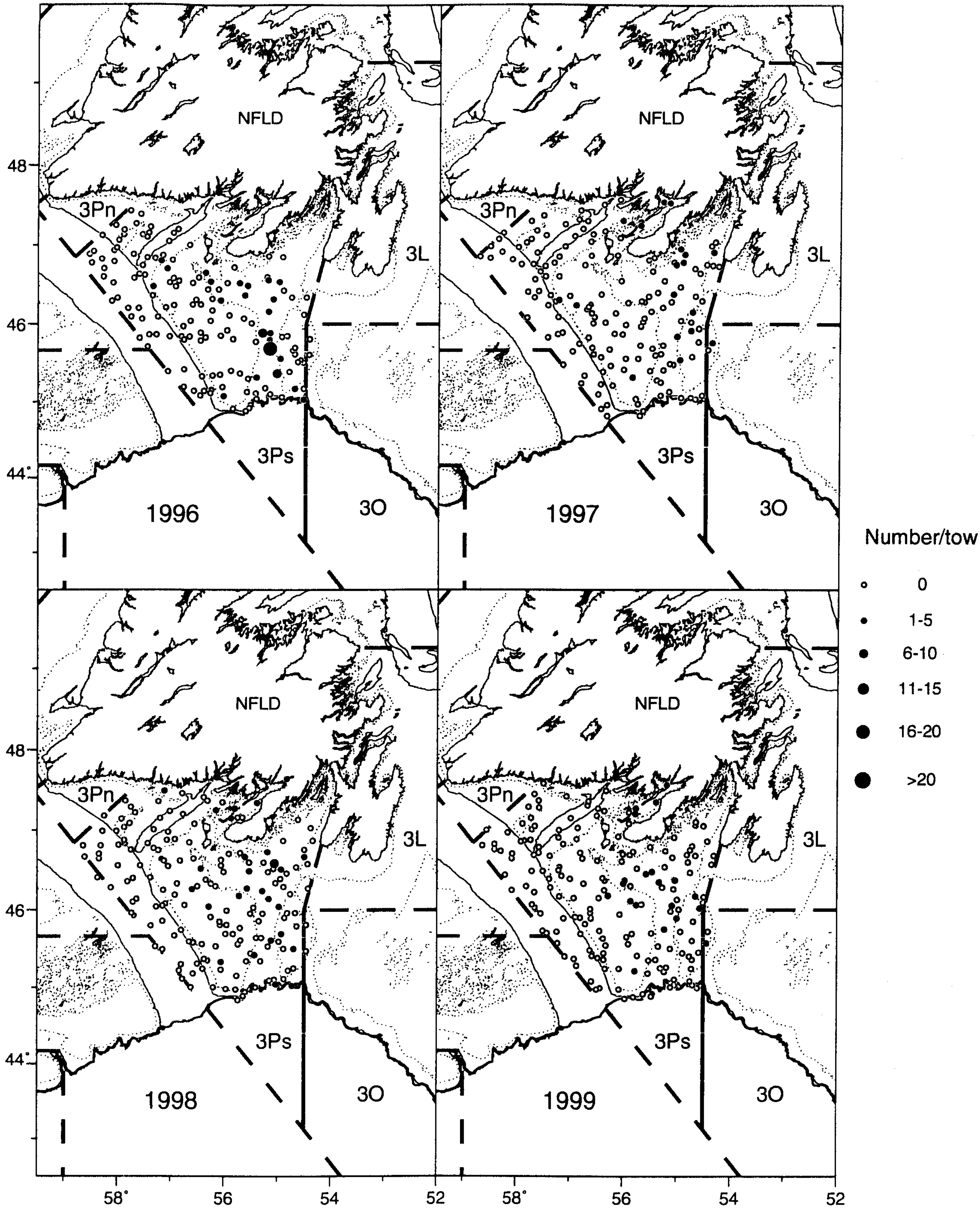

Figure 13c. Distribution of sub-legal 2 males (60-75 mm.) from spring 3P Campelen surveys, 1996-1999.

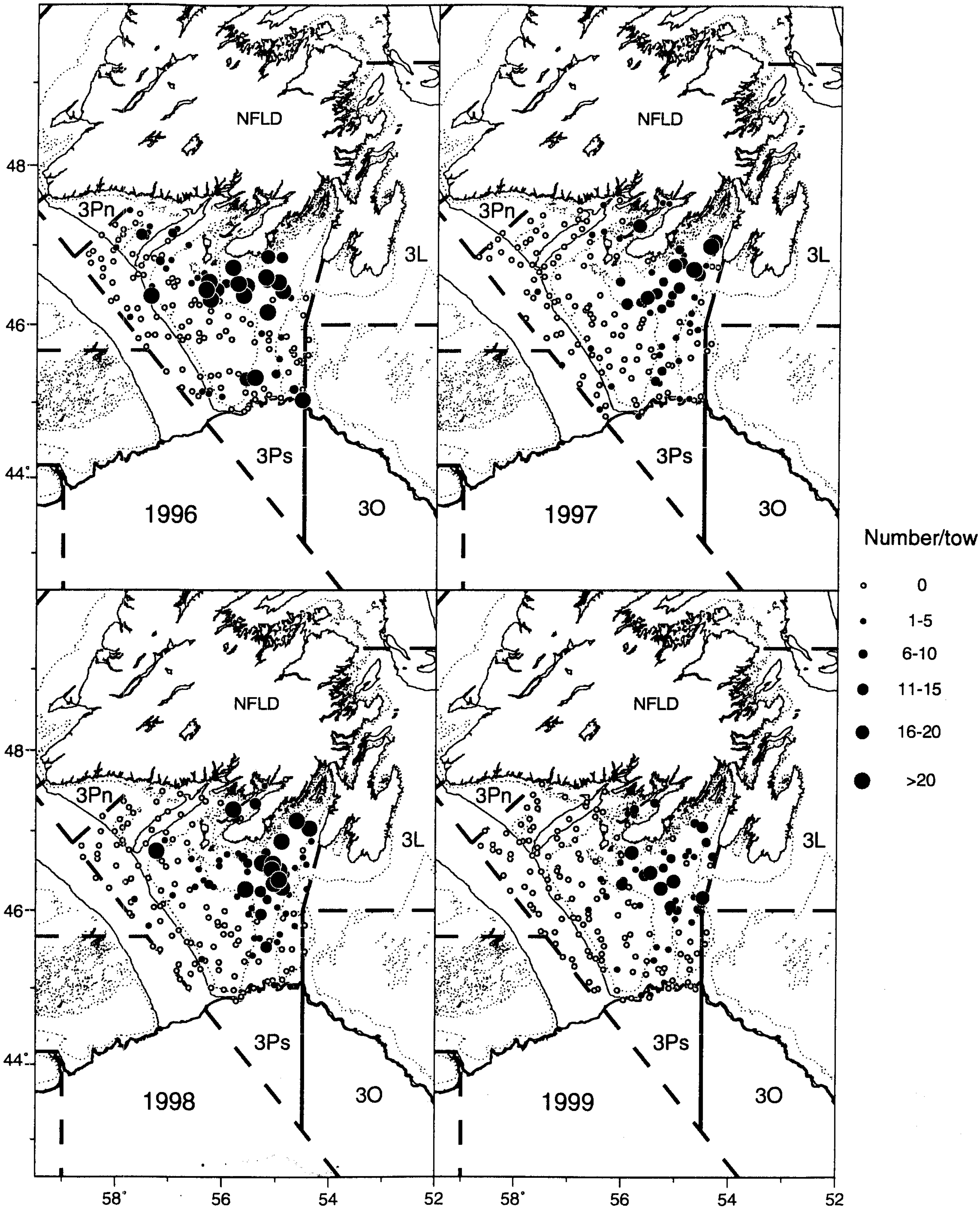

Figure 13d. Distribution of smallest males (<60 mm.) from spring 3P Campelen surveys, 1996-1999.

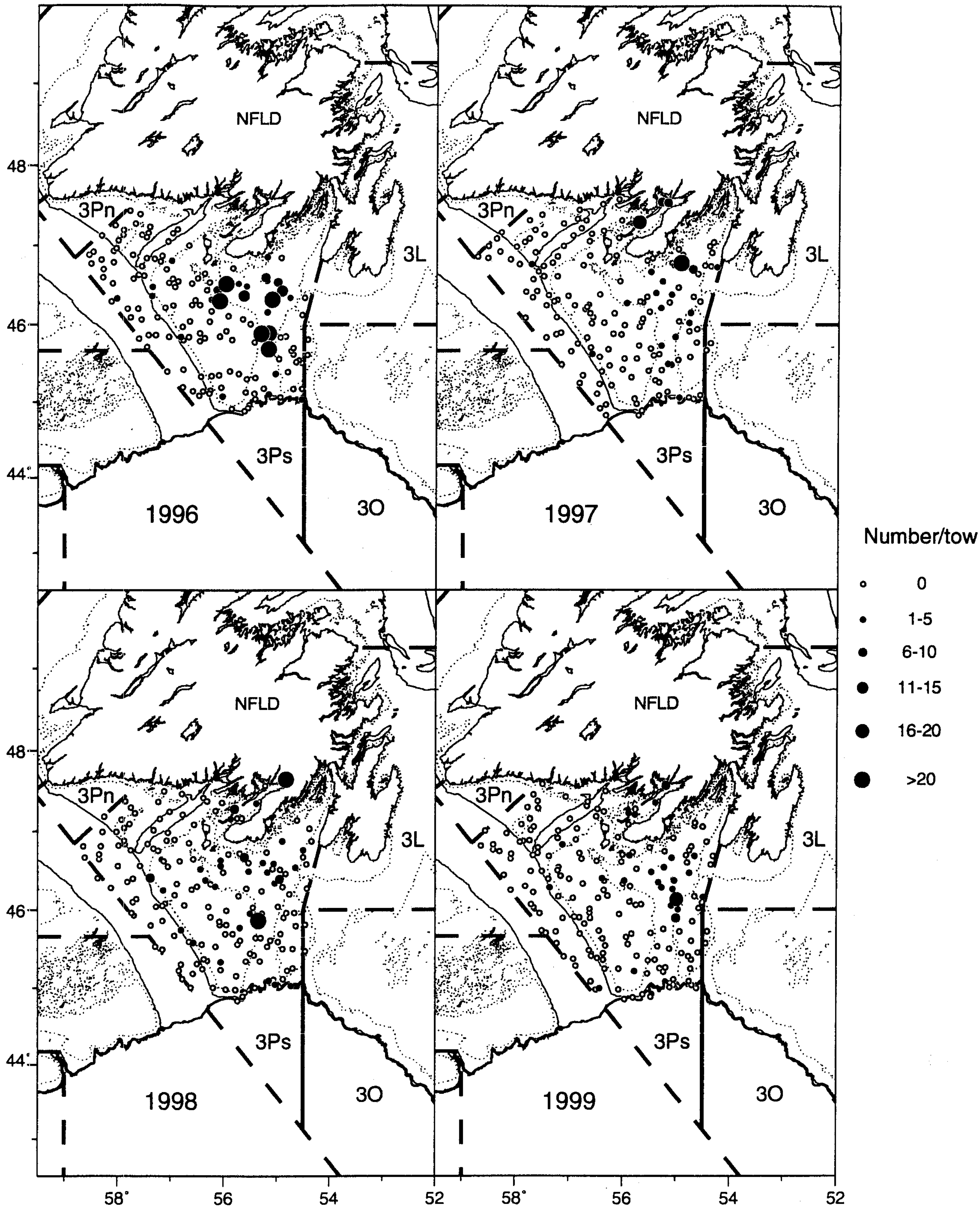

Figure 14. Distribution of mature females from spring 3P Campelen surveys, 1996-1999.

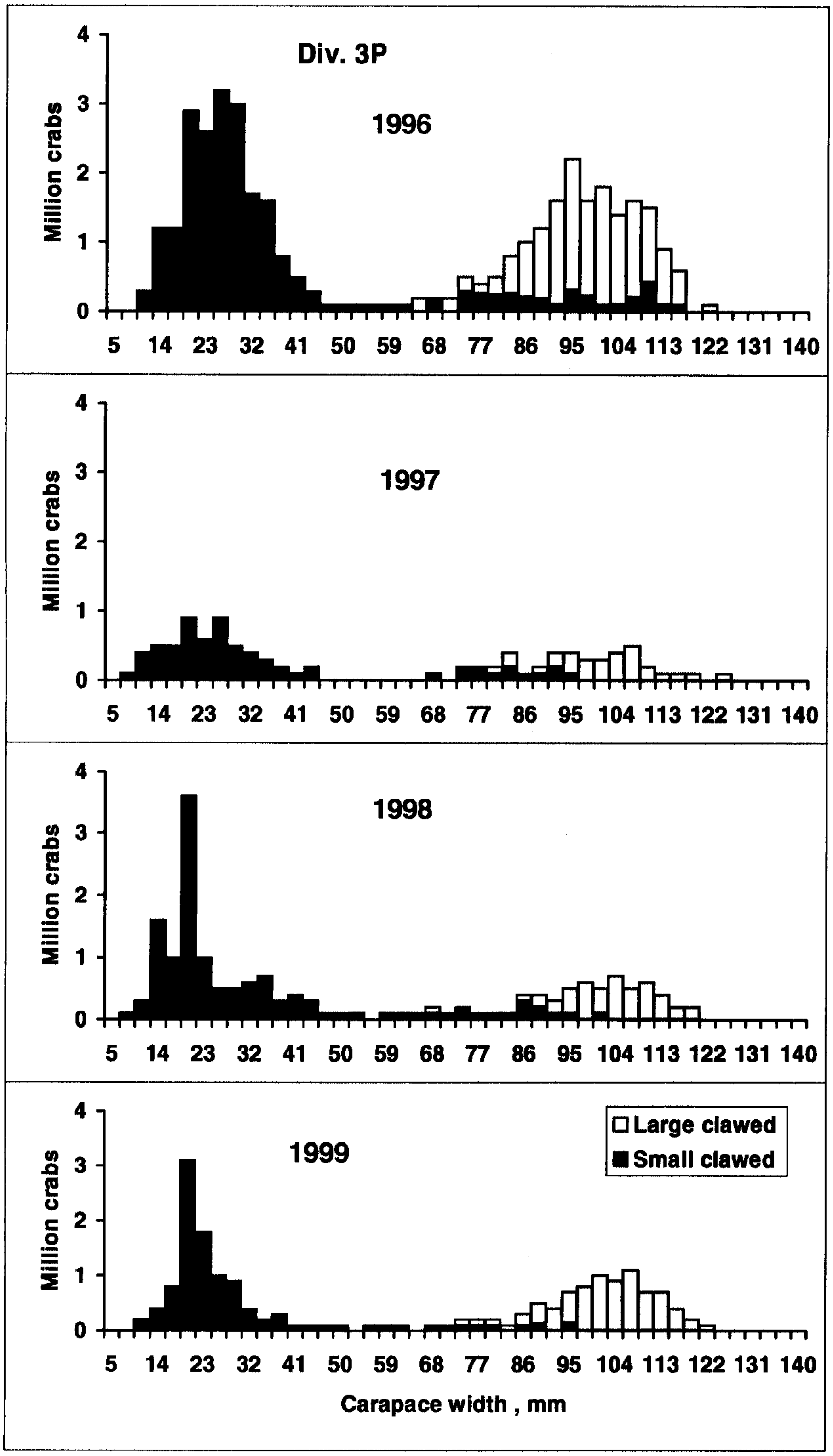

Figure 15. Male size distributions by claw type and year from spring Div. 3P multispecies surveys.