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EVALUATION OF THE TRANSBOUNDARY (CANADA/USA) NATURE OF POLLOCK (*Pollachius virens*)

By

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ABSTRACT

Stone H.H. 2012. Evaluation of the transboundary (Canada/USA) nature of Pollock (*Pollachius virens*). Can. Manuscr. Rep. Fish. Aquat. Sci. 3008: ix + 34p.

The Canada/US International Boundary on Georges Bank (5Z) and in the Gulf of Maine (5Y) is considered to be the southern and western stock limit for the 4VWX5 pollock management unit. In July 2009, GOMAC requested that DFO Science undertake a unilateral investigation on the transboundary nature of pollock to determine if there is any scientific evidence which supports the use of a combined Canada/USA management unit (i.e. SA5&6+4Xopqrs5) or separate management units (status quo) for each nation. This document summarizes information from several sources, including published manuscripts on various aspects of pollock life history, recent stock assessments, Canadian and USA commercial fisheries data, as well as data collected from DFO and NMFS bottom trawl surveys.

No new information on pollock stock structure is available since the last Canadian framework assessment was conducted in 2003. Past scientific evidence generally supports the hypothesis of multiple stocks in the Gulf of Maine/Georges Bank/Scotian Shelf area. It is not known how much movement occurs from western 4X to the Gulf of Maine (*and visa versa*), but both USA and Canadian pollock directed fisheries are more separate geographically now than compared to the past. Recent oceanographic changes associated with *climate change* may have caused a range contraction and an increase in the depth of occurrence of pollock in the Gulf of Maine resulting in greater spatial separation of pollock aggregations.

Pollock catches in USA waters adjacent to the International Boundary (i.e. for eastern 5Yf+5Yb+5Yc+5Zj), represent 6% of Canadian landings, which may not be significant overall from a management perspective. Most of the overlap occurs in an area just west of Sewell Ridge (5Yf). A reduction in allowable “Days at Sea” as a management measure to reduce fishing effort may have limited the number of offshore trips so that much of the USA fishery now occurs in the western Gulf of Maine.

NMFS has recently conducted a benchmark assessment of pollock and their base assumption for stock structure was to treat the USA portion of Areas 5&6 as a unit stock. They also conducted a review of all available studies and concluded that there are multiple hypotheses concerning stock structure, each of which can be supported by one study or another.

Unlike the 5Z TRAC stocks (i.e. cod, haddock and yellowtail flounder), the problem with a combined Gulf of Maine/western 4X pollock assessment is that there is no synoptic spatial/temporal survey coverage to develop indices of abundance for the entire region. This would pose problems for a combined area stock assessment. While information from DFO and NMFS surveys indicates that

pollock growth patterns are similar throughout the Gulf of Maine and western Scotian Shelf region, there are differences in size composition and age structure as well as the timing of recent expansion and contraction in spatial distribution and trends in relative abundance which suggest different stock dynamics throughout this region.

Since pollock in the Gulf of Maine and western 4X are comprised of different spawning aggregations, it may be more effective to manage smaller geographic units rather than a single large one to preserve these spawning components. If both USA and Canada manage their respective stocks conservatively, then pollock abundance in both areas should remain relatively stable. Based on the available information at the time of this review, it is concluded that Canada should continue to assess the Western Stock Component separately from the USA SA5&6 stock.

The New England Fishery Management Council has developed new management measures which include a cap on the amount of groundfish that are permitted to be caught. Fishing vessels may now fish as a group or sector which will be given a portion of the total available groundfish catch based on the combined history of their member vessels. This system will essentially replace the days at sea limit to reduce fishing effort. Consequently, it may be necessary to re-evaluate the spatial distribution of USA pollock catches in a few years time, particularly if fishing activity increases near the international boundary in the Gulf of Maine and on Georges Bank.

RÉSUMÉ

Stone H.H. 2012. Evaluation of the transboundary (Canada/USA) nature of Pollock (*Pollachius virens*). Can. Manuscr. Rep. Fish. Aquat. Sci. 3008: ix + 34p.

La frontière internationale canado-américaine sur le banc Georges (5Z) et dans le golfe du Maine (5Y) est considérée comme étant la limite nord et ouest du stock de la zone de gestion de la goberge dans 4VWX5. En juillet 2009, le Gulf of Maine Advisory Committee a demandé au Secteur des sciences du MPO d'ouvrir une enquête unilatérale sur la nature transfrontalière de la goberge pour déterminer s'il existe des preuves scientifiques appuyant l'utilisation d'une unité de gestion canado-américaine combinée (p. ex. SA 5 et 6 + 4Xopqrs5) ou d'unités de gestion distinctes (status quo) pour chaque pays. Le présent document résume les renseignements provenant de plusieurs sources, y compris les manuscrits publiés portants sur divers aspects du cycle biologique de la goberge, les récentes évaluations du stock, les données sur les pêches commerciales américaines et canadiennes, ainsi que les données provenant des relevés au chalut de fond du MPO et du National Marine Fisheries Service.

Il n'y a pas eu de nouveaux renseignements disponibles sur la structure du stock de goberges depuis la dernière évaluation du cadre menée en 2003. Dans l'ensemble, les preuves scientifiques antérieures appuient l'hypothèse de stocks multiples dans le golfe du Maine, sur le banc Georges et sur le plateau néo-écossais. On ne sait pas combien de déplacements se font de l'ouest de l'unité 4X au golfe du Maine (et vice-versa), mais les pêches dirigées de goberges canadiennes et américaines sont plus éloignées géographiquement aujourd'hui que dans le passé. De récents changements océanographiques associés au *changement climatique* peuvent avoir causé une contraction de l'aire et une augmentation de la profondeur de la présence de la goberge dans le golfe du Maine, donnant lieu à une séparation spatiale plus importante des concentrations de goberges.

Les captures de goberges, dans les eaux américaines adjacentes à la frontière internationale (c.-à-d. pour l'est des unités 5Yf, 5Yb, 5Yc et 5Zj), représentent 6 % des débarquements canadiens, ce qui peut ne pas être globalement important d'un point de vue de gestion. La majorité du chevauchement se produit dans la zone située juste à l'ouest de Sewell Ridge (5Yf). Il se peut que la réduction du nombre de « jours en mer » autorisés, à titre de mesure de gestion visant à réduire les efforts de pêche, ait limité le nombre de déplacements au large des côtes, à tel point que la majorité des pêches américaines se fait désormais à l'ouest du golfe du Maine.

Le National Marine Fisheries Service a récemment mené une évaluation du point de référence de la goberge. Son hypothèse de base relativement à la structure du stock était de considérer la partie américaine des unités 5 et 6 comme un stock indépendant. Il a également passé en revue toutes les études disponibles

et a conclu qu'il existait de multiples hypothèses quant à la structure du stock, chacune d'entre elles pouvant être appuyée par une étude ou par une autre.

Contrairement aux stocks du Comité d'évaluation des ressources transfrontalières (5Z) (c.-à-d. morue, aiglefin et limande à queue jaune), le problème d'une évaluation de la goberge combinée dans l'ouest de l'unité de gestion 4X et dans le golfe du Maine est qu'il n'existe aucune couverture de relevé spatiotemporel synoptique pour établir des indices de l'abondance dans la région entière. Cela poserait un problème pour la réalisation d'une évaluation combinée des stocks de la zone. Bien que les relevés du National Marine Fisheries Service et du MPO indiquent que les schémas de croissance sont semblables dans le golfe du Maine et dans la région de l’ouest du plateau néo-écossais, il existe des différences de la composition selon la taille et de la structure selon l'âge, ainsi que le moment de l'expansion et de la contraction récentes de la répartition spatiale et des tendances de l'abondance relative qui suggèrent une dynamique de stock différente dans cette région.

Étant donné que la goberge se trouvant dans le golfe du Maine et dans l'ouest de l'unité 4X comprend différentes concentrations de frayeurs, il serait peut-être plus efficace de gérer de plus petites unités géographiques plutôt qu'une seule grande unité pour conserver ces composants de frai. Si le Canada et les États-Unis gèrent prudemment leurs stocks respectifs, l'abondance de goberge dans les deux zones devrait demeurer relativement stable. En se fondant sur les renseignements disponibles au moment du présent examen, on a conclu que le Canada devait continuer d'évaluer la composante Ouest du stock séparément du stock des unités SA 5 et 6 des États-Unis.

Le New England Fishery Management Council a établi de nouvelles mesures de gestion comprenant notamment un plafond quant à la quantité de poisson de fond qu'il est autorisé de capturer. Les bateaux de pêche peuvent maintenant pêcher en groupe ou par secteur, auquel ont attribuera une partie des prises totales de poisson de fond disponibles, en fonction de l'historique de leurs bateaux. Ce système remplacera essentiellement la limite du nombre de jours en mer pour réduire l'effort de pêche. Par conséquent, il sera peut-être nécessaire de réévaluer la répartition spatiale des captures de goberges américaines dans quelques années, en particulier si les activités de pêche augmentent près de la frontière internationale dans le golfe du Maine et sur le banc Georges.

INTRODUCTION

Currently, the Canada/US International Boundary on Georges Bank (5Z) and in the Gulf of Maine (5Y) is considered to be the southern and western stock limit for the 4VWX5 pollock management unit. In July 2009, the Gulf of Maine Advisory Committee (GOMAC) requested that the Department of Fisheries and Oceans (DFO) Science Branch undertake a unilateral investigation on the transboundary nature of pollock to determine if there is any scientific evidence which supports the use of a combined Canada/USA management unit (i.e. Subareas (SA) 5&6+4Xopqrs5) or separate management units (status quo) for each nation (Fig. 1). The main issue is: *are pollock in the USA Gulf of Maine sufficiently separate from pollock on the CDN part of Georges Bank and western 4X to warrant separate stock assessments*?

The Terms of Reference for this evaluation were to:

- Review current knowledge of spatial distribution, movements and stock structure of pollock based on USA National Marine Fisheries Service (NMFS) and DFO research vessel (RV) surveys, Canadian and USA commercial fisheries, and published information from tagging studies, genetic analyses and meristic studies.

- Examine the fishery length composition, catch at age and weight at age for appropriate components of the population and examine the catch at age for consistency in tracking the same year class.

- Examine NMFS and DFO biomass indices for consistency in trends and age-specific indices for consistency in tracking the same year class.

- Discuss the suitability of available fishery catch at age and survey indices of abundance for the candidate management unit options.

- Evaluate options for management units that can be used to regulate fishing mortality, discussing potential advantages and limitations of each in relation to uncertainties about stock structure.

This document summarizes information from several sources, including published manuscripts on various aspects of pollock life history, recent stock assessments, Canadian and USA commercial fisheries data, as well as data collected from DFO and NMFS bottom trawl surveys.

REVIEW OF MANAGEMENT HISTORY

Prior to 1973 pollock catches were unregulated. The initial management unit was established by the International Council for North Atlantic Fisheries (ICNAF) in 1973 and included Divisions 4X and Area 5. In 1974, ICNAF expanded the management unit to include Divisions 4V and 4W. The rationale for this expansion was that it would reduce the incidence of misreporting. Pollock on the Scotian Shelf, Georges Bank and Gulf of Maine (4VWX+SA5&6) was assessed as a unit stock by Canada and the USA from 1974 to 1989, with the first Canadian analytical assessment conducted in 1978 (Cleary, 1978).

Following the establishment of the International Maritime Boundary in 1986, Canada conducted a review of the stock structure of marine resources on Georges Bank and in the Gulf of Maine including information on egg and larval distributions, fishery distributions, meristic and morphometric parameters, genetics and preliminary results from mark-recapture studies (Bowen, 1987). It was concluded from this evaluation that "*the amount of transboundary movement was not sufficient to seriously affect stock conservation benefits if Canada undertook unilateral management actions within its own waters*". In 1989, a new Canadian management unit for pollock in 4VWX5 was established and Canada conducted unilateral assessments of pollock as a unit stock within the new management zone from 1989 to 1999.

Since new research on pollock movements and growth patterns was becoming available, a framework assessment of the 4VWX5 pollock stock was conducted in 2003 which re-examined the stock structure of pollock using information from the commercial fishery, RV surveys on various life history stages, population parameters, meristic/morphometric data and mark-recapture information (Neilson et al., 2003). Based on this analysis, Neilson et al. (2003) concluded that the *status quo* option of a single management unit for 4VWX5 was not consistent with available information on population complexity and recommended that western and eastern areas of the 4VWX5 stock should be managed separately. This led to the creation of an "Eastern Stock Component Area" (4VW+4Xmn), where pollock are slower growing and a "Western Stock Component Area" (4Xopqrs+5Zc+5Yb) where pollock are faster growing (Fig. 2). While the boundaries delineating the Eastern Component (i.e. Laurentian Channel, eastern 4X) were considered appropriate, it was difficult to determine where the southern and western boundaries should be located on Georges Bank and in the Gulf of Maine for the Western Component. Neilson *et al.* (2003) proposed retaining the International Boundary as the southern stock limit, a view that was largely based on "pragmatic considerations" until further research could better define the stock boundary.

The USA view on stock structure was that pollock on the Scotian Shelf and Subarea 5 belonged to a single unit stock. Mayo *et al.* (1989) reviewed distributional information, meristic and morphometric data and genetic studies

and concluded that "*the available information did not allow them to refute the hypothesis of a single unit stock throughout Divisions 4VWX and Subareas 5&6*". The USA continued to assess the pollock resource as a unit stock (4VWX+SA5&6) up until 1993 when the last complete age-based assessment was conducted. No analytical assessments were completed by the USA until 2000, when they began using an "index-based" method to evaluate the status of the Georges Bank/Gulf of Maine portion of the stock (SA 5&6) (Mayo 2001, 2002). This assessment approach is still being used although new age structured models are currently being evaluated as part of the 2010 benchmark assessment review.

REVIEW OF STOCK DEFINITION STUDIES

One of the earliest comments on pollock stock structure appears in an unpublished manuscript of Vladykov (1932) who compared the timing of the pollock fishery in Charlotte County to that off Gloucester, Massachusetts. Vladykov considered that the same fish supported both fisheries and moved seasonally into the Bay of Fundy as water temperatures warmed in the summer, then departed in the fall, supporting the fall/winter Gloucester fishery. Steele (1963) examined later fisheries data and reached a similar conclusion.

On the basis of fishery distribution information from 1962 to 1966, Kohler (1968) postulated that there were three pollock stocks: Bay of Fundy and approaches, Browns Bank east to the 4X/4W line and east of the 4X/4W line. The proposed boundaries appeared to reflect discontinuities in the fishery distribution. Hare (1977) reviewed stocks of groundfish on the Scotian Shelf and identified four pollock stocks in the Gulf of Maine/Scotian Shelf region: 1) Southern Gulf of Maine, 2) Georges Bank, 3) lower Bay of Fundy/southwest Nova Scotia, and 4) central Scotian Shelf. This interpretation differed from Kohler (1968) in that it did not recognize a separate component at the mouth of the Bay of Fundy. Hare (1977) also showed connections among the stock components, but it is unclear how such linkages were made.

McGlade *et al.* (1983) collected pollock samples from Emerald Basin, Browns Bank and Jeffreys Ledge and analyzed phenotypic differences in shape as a function of size (truss analysis) and then conducted multivatiate statistical analysis of meristic characteristics and morphometric measurements (McGlade and Boulding, 1986). Significant differences occurred among fish from the three areas. MaGlade *et al.* (1983) also conducted electrophoretic analysis of 28 enzyme systems in pollock tissue from fish sampled in Emerald Basin and Jeffreys Ledge, but no significant genetic differences occurred between the two areas. In combination, these studies did not provide a conclusive definition of pollock stock structure.

Mayo *et al.* (1989) developed composite distribution plots of pollock eggs and larvae based on USA and Canadian ichthyoplankton surveys conducted in the 1970s and 1980s (Fig. 3). This data showed a peak in spawning from November through February and that there may be several spawning areas within the Georges Bank, Scotian Shelf and Gulf of Maine Region. More recently, Hanke *et al.* (2001) developed composite plots of all Canadian ichthyoplankton survey data from the 1970s to 1990s for early life history stages of pollock (Fig. 4). Prime spawning areas inferred from the spatial extent of stage I and II eggs were: Georges Bank, Browns Bank, southwestern Nova Scotia (coastal and offshore), Emerald/Western Bank as well as The Gully on the eastern Scotian Shelf. The presence of temporal and spatial discontinuities in stage I and II egg distribution in the Gulf of Maine and on the Scotian Shelf clearly supports the conclusion that pollock are comprised of a complex of separate spawning components.

CANADIAN AND USA COMMERCIAL FISHERIES

Landings and Fishery Distribution

Both Canadian and USA commercial fisheries data are available in electronic format back to 1982 and provide information on temporal and spatial trends in catches and fishery distribution, catch at size, catch age and mean weight at age for comparisons between the Gulf of Maine (USA) and western 4X5 (Canada).

Canadian landings for the Western Component exceeded those from Areas 5&6 every year from 1987 through 2005, after which the quota was reduced to 5000 t and Canadian landings dropped below those from the USA (Fig. 5). Canadian landings from the Eastern Component also exceeded USA landings up to about 1993, but declined thereafter due to the closure of the eastern Scotian shelf for cod and haddock directed fishing. Since 2002, USA landings in areas 5&6 (Gulf of Maine) have been increasing and in 2008 were 10,000 t, more than double the Canadian landings for Western Component that year (4,100 t).

During the 1980s, USA mobile gear catches of pollock occurred across the Gulf of Maine and northern Georges Bank and beyond the International Boundary (Fig. 6). (Note: Prior to 1985, both Canada and the USA fished in what is now Canadian waters on northeastern Georges Bank). In the 1990s, USA mobile gear catches were still fairly widespread across Gulf of Maine to the International Boundary but there were fewer areas with good catches. Gill net catches in the 1980s and 1990s occurred mainly in the western Gulf of Maine but also in the east near the Hague Line around Sewell Ridge. During the 2000s, mobile gear catches declined further and occurred mainly in the western Gulf of Maine in the Wilkinson Basin area, especially over the past four years (Fig. 7). Gill net catches also occurred mainly in the western Gulf of Maine on Jeffreys Ledge, Stellwagon Bank and Cashes Ledge.

During 1980s and early 1990s, there was a significant Canadian fishery for pollock on the Eastern and Western Scotian Shelf (Fig. 8; left panel). In 1993, the Eastern Scotian Shelf was closed to cod and haddock directed fishing which reduced pollock landings from that area. The Canadian fishery in the 1990s was mostly on the central and western Scotian Shelf up to international boundary (Fig. 8; right panel). Canadian bottom trawl catches now occur mainly in Crowell and Jordan Basins (4Xpq), the eastern Bay of Fundy, northeastern Georges Bank, along shelf slope (4Xn) and east of La Have Bank (Fig. 9; left panel). Gillnet catches are mainly in the Jordan Basin area (4Xq), northeastern Georges Bank, around the edges of LaHave and Emerald Basins and on Baccaro and LaHave Banks (Fig. 9; right panel). Mobile gear catches extend up to International Boundary in the Gulf of Maine and on Georges Bank but less so for gillnet. The highest catches near the boundary occur around Sewell Ridge.

USA fishery landings by statistical unit area were combined to represent inshore (5Yc+5Yd+5Ye+5Zg) and offshore (5Yf+5Zh+5Zj) regions (Fig. 10). Landings from the inshore region increased after 2002 from 2000 t to 7000 t, while landings from offshore have fluctuated around 1700 t (Fig. 11). A reduction in available days at sea for both fixed and mobile gear (to reduce fishing effort) may have reduced the number of offshore trips since 2002. Between 1998 and 2008, the average trip length also declined from 7 to 5 days.

Pollock landings from unit areas adjacent to the Hague Line in USA waters were examined to determine the proportion of total catches that occur in this region. Landings from 5Yf and 5Yc east of 68^{o}00'N and 5Zj east of 67^{o}40'N (where a break in fishery distribution occurs), were combined and compared with total USA and Canadian fishery landings**.** Between 1982 and 2008, USA fishery landings from this area have ranged from 200 t to 1400 t (average = 564 t) (Fig. 12; upper panel) and were generally below 10% of total Canadian and USA landings, except for the recent period when Canadian quotas were reduced (Fig. 12; lower panel). USA catches adjacent to the Hague Line have averaged 6% of total Canadian landings for the Western Component and 7% of total USA landings for SA5&6 from 1982 to 2008.

Catch at Size, Catch at Age and Weight at Age Comparisons

Overall, the USA commercial fishery tends to catch larger pollock compared to Canadian fishery (mode: 70-75 cm for USA *vs* 55-60 cm for Canada) (Fig. 13). However, nearly half of the USA catch comes from gillnet which would select for larger sized pollock, while in the Canadian fishery, the largest share comes from bottom trawl which would retain a greater proportion of small pollock. In the USA fishery, bottom trawl catches represent on average, about 56% of total landings compared to 44% for gillnet (Fig. 14). In the Canadian fishery, bottom trawl represents about 66% compared to 24% for gillnet. The contribution to overall landings by gear type will influence the size composition of the catch as well as differences in mesh size regulations between nations (i.e. the minimum gillnet

mesh size for USA is 165 mm *vs* 140 mm for Canada and the minimum cod end mesh size for USA is 165 mm square or diamond *vs* 130 mm square for Canada).

There is a period of much diminished numbers at age for older ages during the 1990s in the catch at age for both nations with evidence of rebuilding in recent years (Fig. 15). More older pollock (age 7+) have been present in the USA fishery compared to the Canadian fishery since 2005 while more younger fish (ages 3-5) occur in the Canadian fishery overall. These differences could reflect the differences in minimum mesh size between nations with the larger USA mesh allowing for greater escapement of younger fish which eventually recruit to older age groups.

The fishery weights at age (WAA) for Canadian and USA fisheries exhibit similar trends for ages 3-6, with a general decline from the early 1980s to early 2000s, increasing in recent years (Fig. 16). The USA fishery WAA tends to be lower than the Canadian WAA for ages 3-4, similar for ages 5-6 but variable for ages 7-8. These patterns likely reflect similar growth conditions in the Gulf of Maine, northeastern Georges Bank and western 4X regions for ages 3-6 and recently for ages 7-8.

NMFS AND DFO SURVEYS

The USA National Marine Fisheries Service (NMFS) has conducted stratified random bottom trawl surveys during spring and fall in the Gulf of Maine/Georges Bank region since the 1960s. Similarly, the Canadian Department of Fisheries and Oceans (DFO) has conducted bottom trawl surveys of the Scotian Shelf and Bay of Fundy during summer since the 1970s and on Georges Bank in late winter since the mid-1980s. While these series do not provide synoptic coverage of the Gulf of Maine/western Scotian Shelf area (i.e. SA 5&6 + Div. 4X), which would be problematic for a combined Canada/US assessment of the entire region, they do provide a useful time series illustrating trends in spatial distribution, relative biomass (kg/tow), length at age (LAA) and age composition (catch at age).

Geographic Distribution and Relative Abundance

The NMFS spring and fall surveys show widespread distribution and good catches of pollock across Gulf of Maine in USA and Canadian waters during the 1970s (Fig. 17). While pollock catches in these surveys were somewhat lower in the1980s, they were still fairly widespread across the Gulf of Maine. During the 1990s the NMFS surveys show a continued decline in catches in the Gulf of Maine, with some rebuilding in the 2000s in the western Gulf of Maine around Wilkinson Basin, but the geographic distribution is no longer as widespread. The DFO summer survey shows an increase in abundance and distribution from the

1970s to 1980s with an expansion to the eastern Scotian Shelf region. This is followed by a decline in abundance on the eastern Scotian Shelf from the 1990s to 2000s, a decade later than indicated by NMFS surveys in the Gulf of Maine. This difference in timing suggests separate stock dynamics between the Gulf of Maine and Scotian Shelf.

A comparison of trends in pollock biomass (kg/tow) from the NMFS spring, NMFS fall and DFO summer (Western Component) surveys shows strong year-effects in all three series, which reflects the semi-pelagic schooling behaviour of pollock and changes in catchability (Fig. 18). There is some synchrony among the three series in recent decades with a general decline through the 1990s and a subsequent increase in the 2000s. However, the timing of the recent increase differs among surveys, beginning in 2001 for the NMFS fall, 2003 for the DFO summer and 2005 for NMFS spring series.

The DFO Georges Bank winter survey shows a decline in the extent of pollock catches in USA waters below Wilkinson Basin from the 1980s to present (Fig. 19). A persistent feature throughout the time series is the concentration of pollock in Canadian waters on the northeastern part of the bank. While trends in pollock biomass (kg/tow) from the Georges Bank survey tend to be quite variable (Fig. 20), they show a pattern similar to the DFO summer survey for Western 4X, with period of high abundance during 1980s, low abundance in 1990s followed by an increase in the 2000s, suggesting a linkage between these two areas.

Size and Age Composition

A comparison of pollock size frequency distributions indicates that the NMFS spring and fall surveys capture proportionally more small fish (i.e. < 40 cm) in the Gulf of Maine compared to the DFO summer survey in western 4X and the DFO winter survey on Georges Bank (Fig. 21). The NMFS surveys also show a modal progression in size from spring to fall (i.e. from 20 cm to 30 cm Fork Length). This difference may reflect better coverage of nearshore habitats by the NMFS surveys where small pollock are found. In contrast, the DFO surveys on Georges Bank and western 4X catch proportionally more large fish (i.e. > 40 cm). Pollock captured from both DFO series tend to be similar in size which may indicate connectivity between eastern Georges Bank and western 4X.

Bubble plots of stratified mean catch/tow at age for the DFO summer (Western 4X), NMFS spring and NMFS fall surveys show a decline in abundance of age 7+ pollock during the 1990s up to mid-2000s with a modest improvement in age structure since 2005 (Fig. 22). Strong year effects occur in all three time series which makes it difficult to track year classes. Noteworthy is that the NMFS surveys capture more younger fish (Age 2) and possibly more older fish (Age 7+) compared to the DFO summer survey.

Length at Age

In terms of growth, the length at age (LAA) of pollock for ages 2-5 tends to be lowest for the NMFS spring survey, intermediate for DFO summer survey (Western 4X) and highest for NMFS fall survey (Fig. 23). These differences in part reflect somatic growth during summer and fall for fish aged 2-5; after age 5 this difference is less pronounced as more energy is directed towards maturation/reproductive processes. For all three series, there is a general declining trend in LAA from the 1980s to the late 1990s, followed by a recent increase for some ages. This overall synchrony indicates similar growth patterns/environmental conditions for pollock throughout the Gulf of Maine and western 4X.

REVIEW OF POLLOCK TAGGING STUDIES

One of the first Canadian pollock tagging studies was conducted by Steele (1963) in the outer Bay of Fundy. Steele reported that commercial catches of pollock in the Gulf of Maine showed marked seasonal variation, with high landings in the northern Gulf of Maine during summer/fall and high landings in the southern Gulf of Maine during winter/early spring. To examine movements of pollock in the Bay of Fundy, Steele tagged 1000 fish in July, 1960, with 498 released off Campobello and 502 released off Grand Manan, New Brunswick. Summer/fall recoveries (1960-1962) from commercial fisheries occurred mainly in the Bay of Fundy and off southwestern Nova Scotia while winter/spring recoveries (1960-1962) came from spawning grounds at the mouth of Massachusetts Bay and also off southwestern Nova Scotia (Fig. 24). This pattern of recaptures indicated that some of the pollock found in the Bay of Fundy during summer migrated to spawning grounds in the southern Gulf of Maine during winter while some moved to the area off southwestern Nova Scotia, presumably to spawn as well. Currently, Canadian pollock catches in the western Bay of Fundy (4Xs) are quite low compared to the 1960s, and the group associated with the spawning aggregation in the southern Gulf of Maine may no longer be as abundant.

An extensive pollock tagging program was conducted inshore in the Canadian Maritime provinces from 1978-1984 using FLOY dart tags (Clay *et al.* 1989) (Fig. 25). In this study there were 55,857 releases of pollock aged 2 and under captured from traps and using rod and reel. Between 1979 and1990 there were 5,088 recaptures (9% of total), 71% from otter trawl and 29% from gillnet fisheries. Clay *et al.* (1989) used the initial results from this study to contribute to the knowledge of pollock growth and early life history. Several years later, Neilson *et al.* (2006) conducted detailed analyses of the pollock recaptures (1979-1990) from Clay's releases (1978-1984). The main objective of the Neilson *et al.* (2006) study was to determine the complexity of pollock stock structure in 4VWX5. Recapture information was divided into eastern (4VW) and

western (4X) components and standardized fisheries effort data by statistical area was used to adjust the distribution of tag recovery rates. Among the findings from this work was that 72% of pollock released in the east (4VW) were recaptured in east while 81% of pollock released in west (4X) were recaptured in the west (Fig. 26). Neilson *et al.* (2006) concluded that there was a split between the western and eastern Scotian Shelf. Noteworthy is that 97% of all recaptures occurred in Canadian waters within the 4VWX5 management unit and only 3% occurred outside the management unit in USA waters.

Neilson *et al.* (2006) also noted a difference in the number of Canadian recaptures in USA waters from releases on the western (4Xs) and eastern (4Xr) sides of the Bay of Fundy. On the western side (Fundy Isles), from 15,717 releases there were 403 recaptures, 63 (16%) of which occurred in USA waters. Nelison concluded that some of these fish may be linked with the southern Gulf of Maine spawning group. However, this component, which exhibits a north-south seasonal migration into the Bay of Fundy is currently no longer very significant to the Canadian fishery. Of 6,081 releases on the eastern side of the bay (Brier Island, NS) there were 255 recaptures, with 5 (2%) of these in USA waters. Of 6,515 releases of southwestern Nova Scotia (4Xo), there were 1600 recaptures but only 5 (<1%) occurred in USA waters. This implies that emigration from the eastern Bay of Fundy (4Xs) and southwestern Nova Scotia (4Xo) to USA waters may be minimal.

CONCLUSIONS AND RECOMMENDATIONS

- There is no new information on pollock stock structure available since the last framework assessment was conducted in 2003. Past scientific evidence generally supports the hypothesis of multiple stocks in the Gulf of Maine/Georges Bank/Scotian Shelf area.

- It is not known how much movement occurs from western 4X to the Gulf of Maine (*and visa versa*), but both USA and Canadian pollock directed fisheries are more separate geographically now than compared to the past.

- Recent oceanographic changes associated with *climate change* may have caused a range contraction and an increase in the depth of occurrence of pollock in the Gulf of Maine (Nye at al. 2009) resulting in greater spatial separation of pollock aggregations.

- The mean estimate of pollock catches in USA waters adjacent to the International Boundary is ~ 560 mt (i.e. for eastern 5Yf+5Yb+5Yc+5Zj), or 6% of Canadian landings, which may not be significant overall from a

- A reduction in allowable “Days at Sea” as a management measure to reduce fishing effort may have limited the number of offshore trips so that much of the USA fishery now occurs in the western Gulf of Maine.

- NMFS has recently conducted a benchmark assessment of pollock and their base assumption for stock structure was to treat the USA portion of Areas 5&6 as a unit stock. They also conducted a review of all available studies and concluded that there are multiple hypotheses concerning stock structure, each of which can be supported by one study or another (Northeast Fisheries Science Centre 2010).

- Unlike the 5Z TRAC stocks (i.e. cod, haddock and yellowtail flounder), the problem with a combined Gulf of Maine/western 4X pollock assessment is that there is no synoptic spatial or temporal survey coverage to develop indices of abundance for the entire region. This would pose problems for a combined area stock assessment.

- While information from DFO and NMFS surveys indicates that pollock growth patterns are similar throughout the Gulf of Maine and western Scotian Shelf region, there are differences in size composition and age structure as well as the timing of expansion and contraction in spatial distribution and trends in relative abundance which suggest different stock dynamics throughout this region.

- Since pollock in the Gulf of Maine and western 4X are comprised of different spawning aggregations, it may be more effective to manage smaller geographic units rather than a single large one to preserve these spawning components.

- If both USA and Canada manage their respective stocks conservatively, then pollock abundance in both areas should remain relatively stable. The USA should have better information on stock status in SA 5&6 following the 2010 SAW/SARC assessment process.

- Based on the available information at the time of this review, it is concluded that Canada should continue to assess the Western Stock Component separately from the USA SA5&6 pollock stock.

Update on 50th USA Northeast Regional Stock Assessment Workshop and Potential Implications to the SA 5&6 Pollock Fishery

The recent (June 2010) NMFS stock assessment for pollock in SA 5&6 used a new assessment model (ASAP) which was quite different from the index-based (AIM) model used in the 2009 GARM III assessment. Results from this model indicate that the stock is not overfished, that the 2009 SSB is about 196,000 t and that the MSY proxy is ~ 16,000 t. If the stock is fished at 75% of MSY, the yield would be 12,000 t. This compares to the 2008 estimate of SSB for the CDN Western Component of 27,000 t with a quota of 5,000 t.

The New England Fishery Management Council has developed new groundfish management measures (effective May 1, 2010) to end overfishing and continue the rebuilding of Northeast groundfish such as cod and flounder. For the first time there will be a cap on the amount of groundfish of any species that are permitted to be caught. Fishing vessels may now fish as a group or sector which will be given a portion of the total available groundfish catch based on the combined history of their member vessels. This system will essentially replace the days at sea limit to reduce fishing effort. Therefore, it may be necessary to re-evaluate the spatial distribution of USA pollock catches in a few years time, particularly if fishing activity increases near the international boundary in the Gulf of Maine and on Georges Bank with increased pollock allocations.

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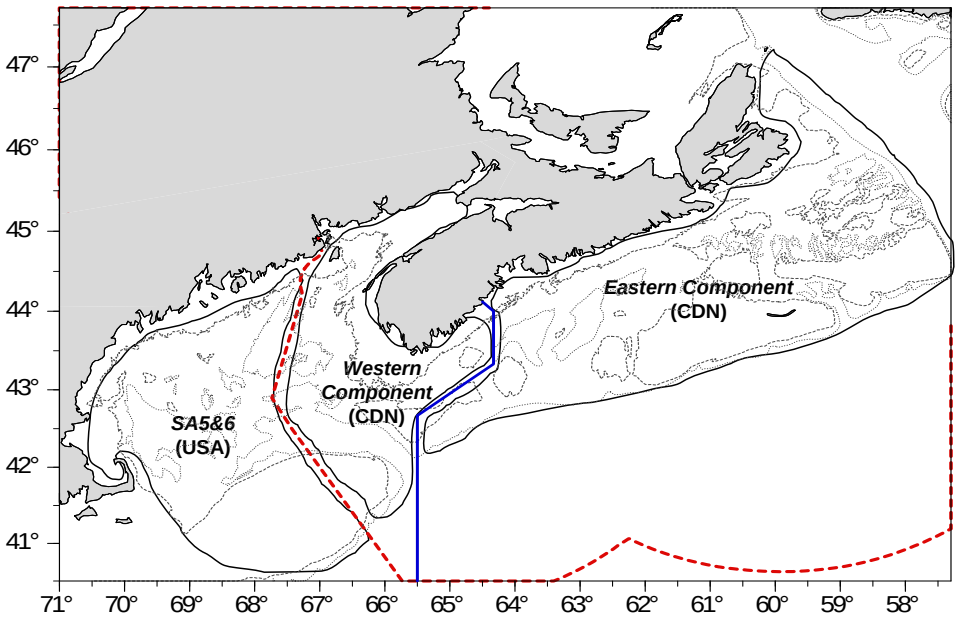

Figure 1. Schematic diagram illustrating current pollock management units for Canada for the Scotian Shelf, Bay of Fundy and eastern Georges Bank (Western and Eastern Components) and the USA Gulf of Maine/George Bank area (Subareas 5&6).

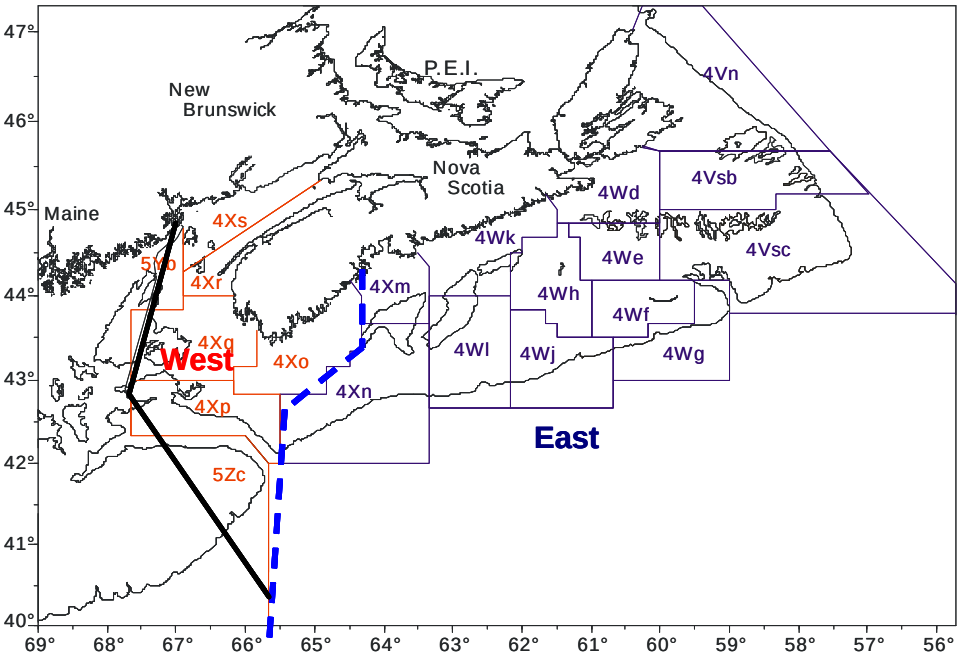

Figure 2. Statistical Unit Areas for the Scotian Shelf, Bay of Fundy and eastern Georges Bank and areas forming the Western and Eastern Stock Components of the 4VWX5 pollock management unit (separated by dashed line).

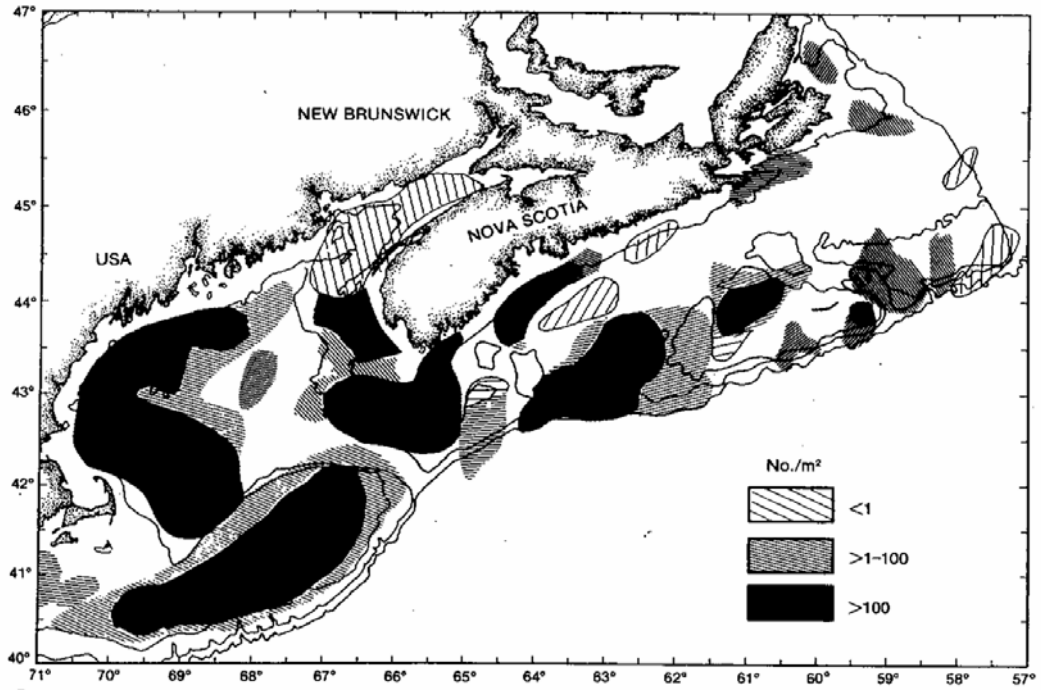

Figure 3. Distribution of pollock eggs and larvae (No/m^2) based on Canadian and USA ichthyoplankton surveys conducted in the 1970s and 1980s in Div. 4VWX and Subareas 5 and 6 (From Mayo et al.1989).

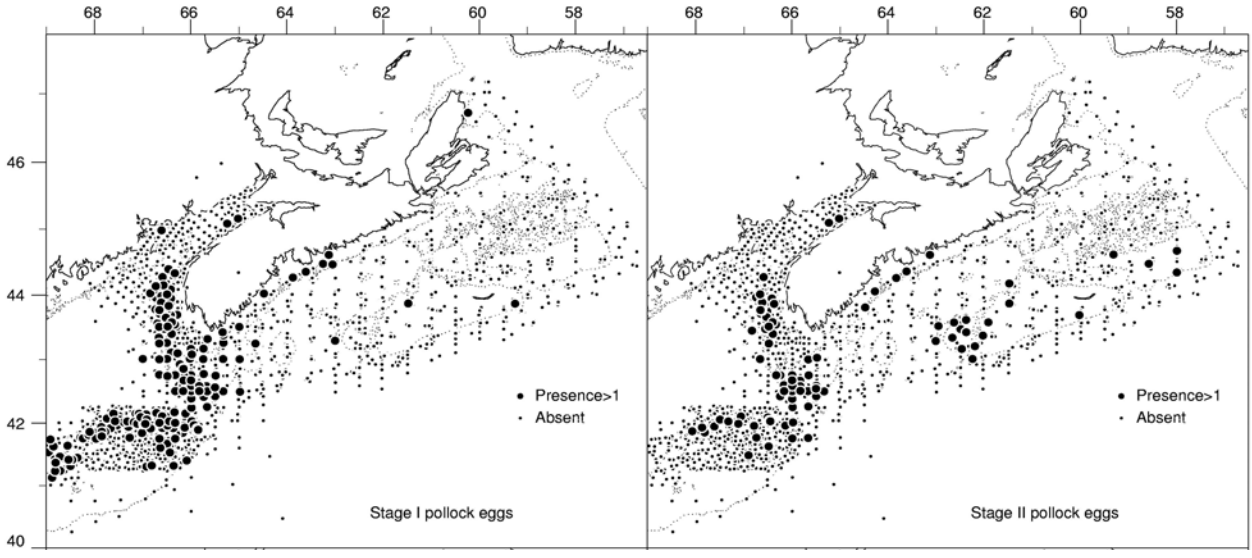

Figure 4. Composite plot of stage I and II pollock eggs (presence/absence) from Canadian ichthyoplankton surveys conducted on the Scotian Shelf/Bay of Fundy and northern Georges Bank from 1975 to1997 (from Hanke et al. 2001).

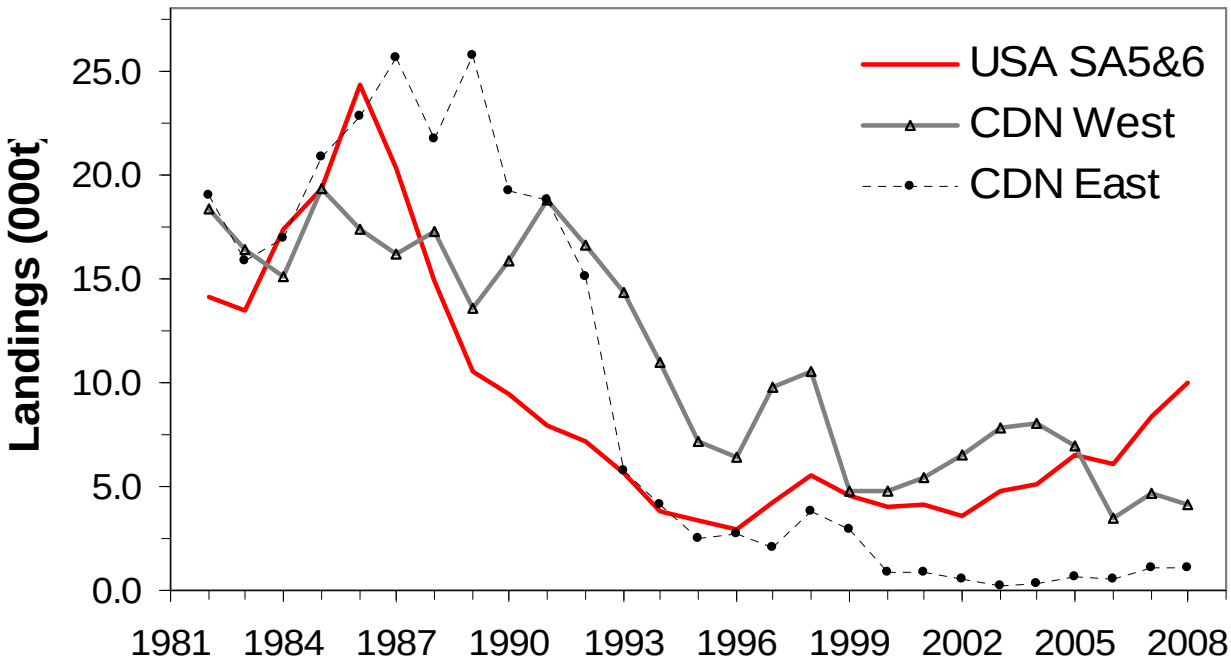

Figure 5. Pollock landings (t) from Canadian Western (4Xopqrs5) and Eastern (4VWXmn) Components, and USA Subareas 5&6, 1982 to 2008.

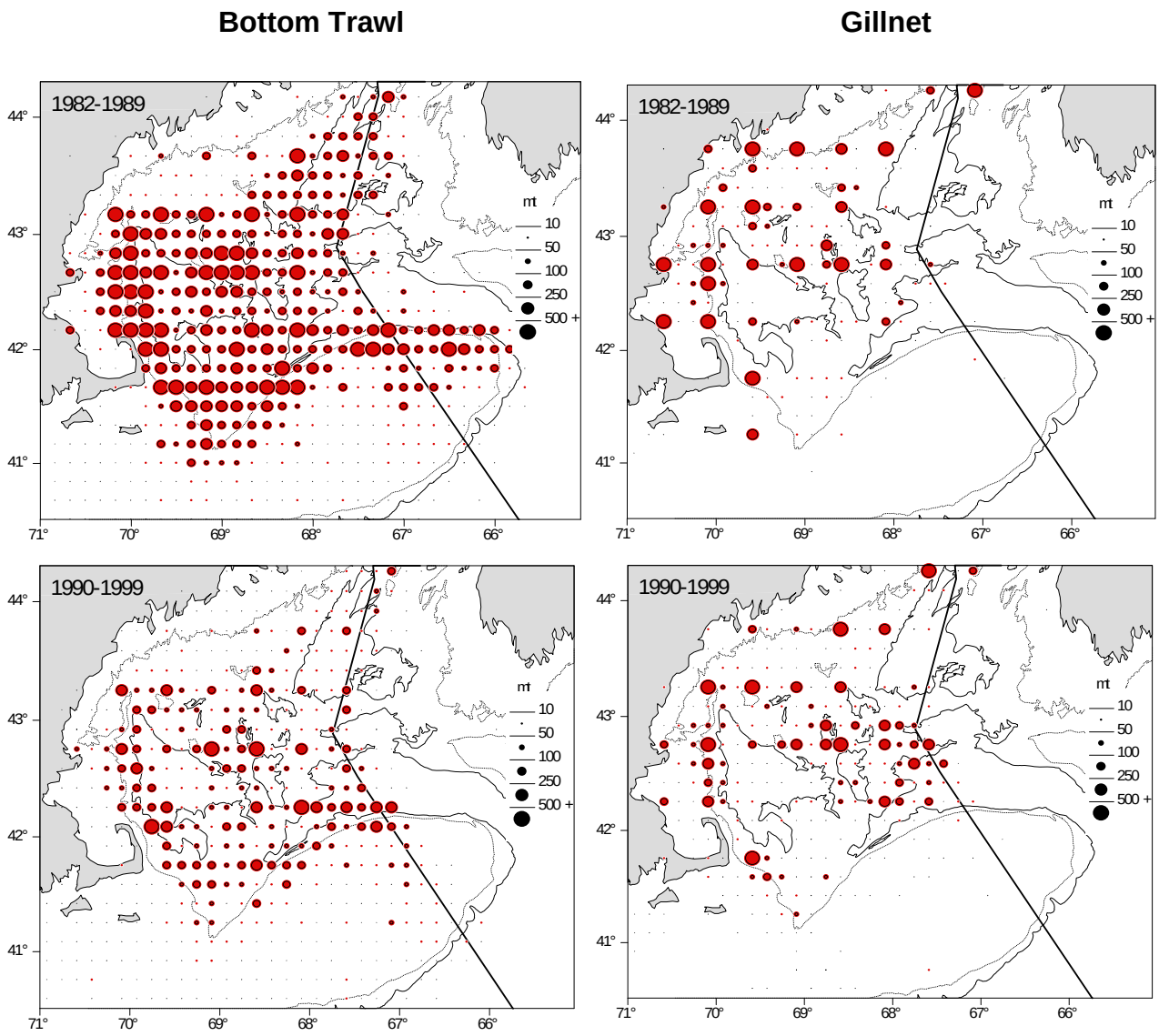

Figure 6. Distribution of USA pollock catches (t) aggregated by 10 minute squares for bottom trawl and gillnet fisheries for 1982 to 1989 and 1990 to 1999.

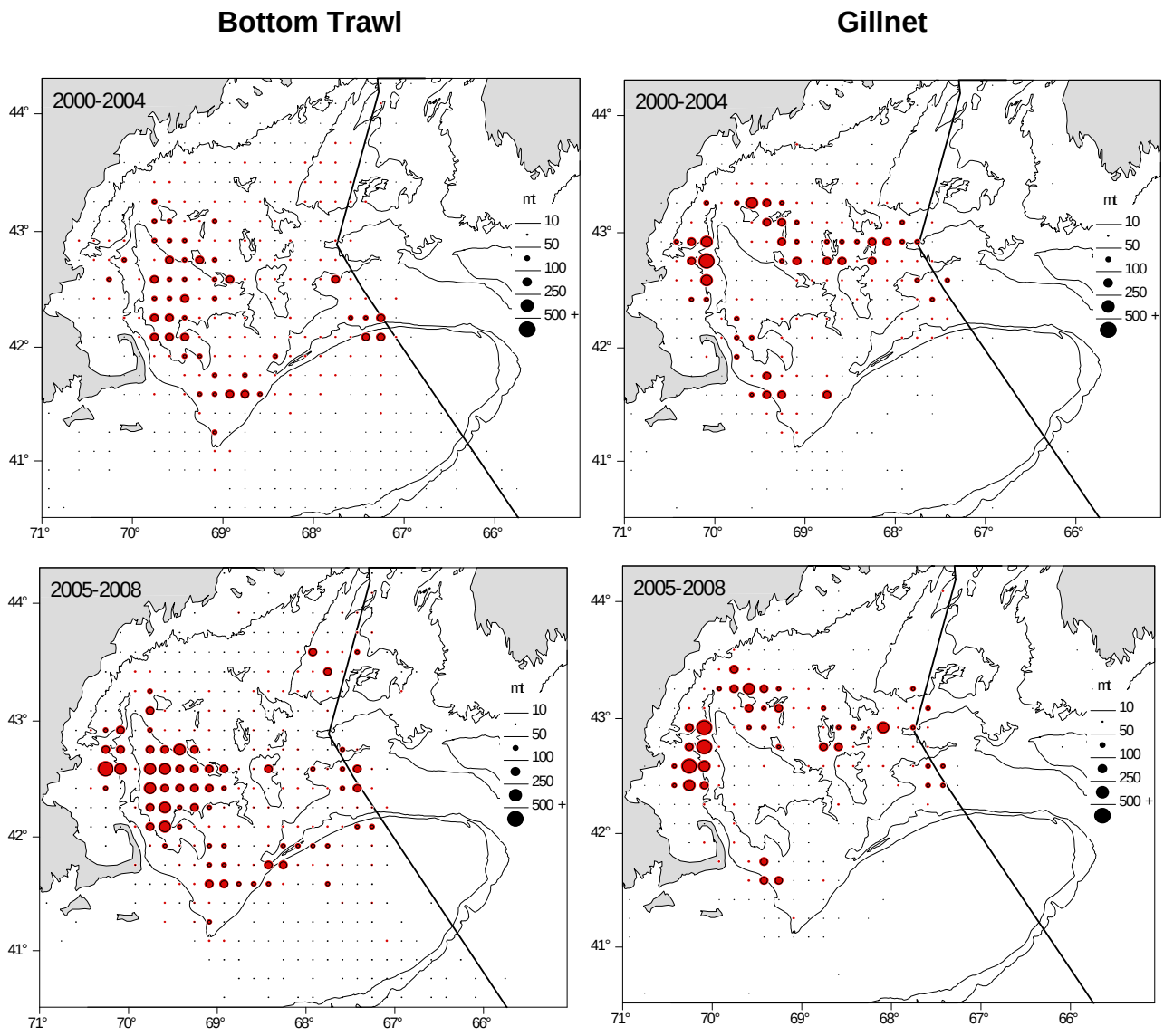

Figure 7 Distribution of USA pollock catches (t) aggregated by 10 minute squares for bottom trawl and gillnet fisheries for 2000 to 2004 and 2005 to 2008.

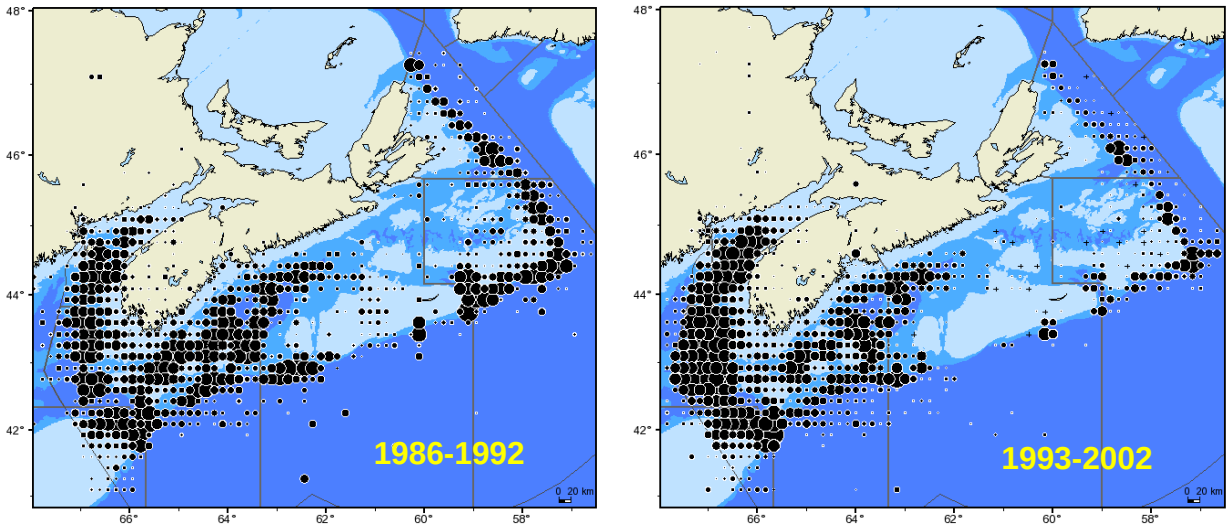

Figure 8. Distribution of Canadian pollock catches (t) for 1986 to1992 (left panel) and 1993 to 2002 (right panel) aggregated by 10 minute squares for all gear types.

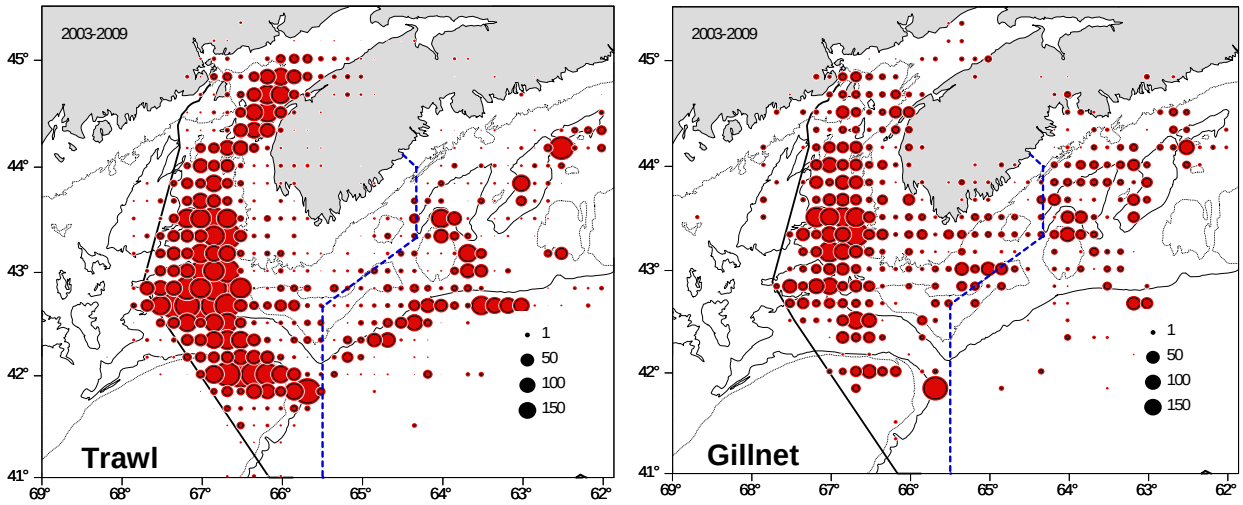

Figure 9. Distribution of Canadian pollock catches (t) for 2003 to 2009 for bottom trawl (left panel) and gill net (right panel) aggregated by 10 minute squares. The dashed line separates Western and Eastern Components.

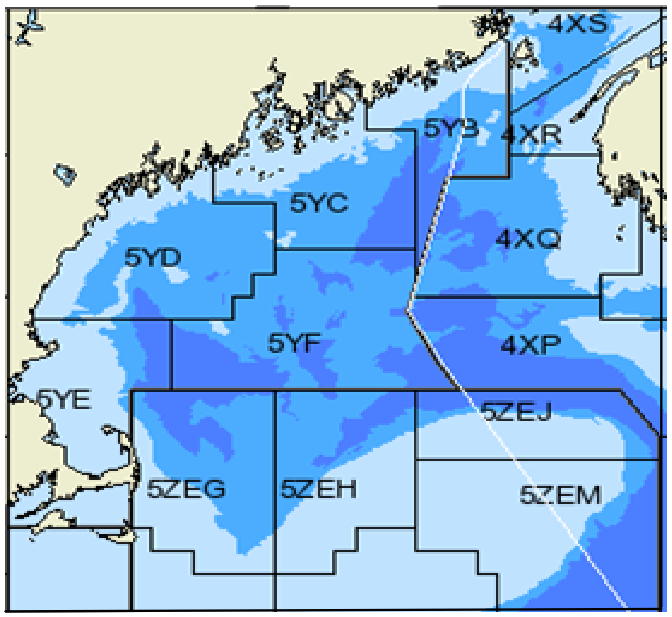

Figure 10. Statistical unit areas for the Gulf of Maine, Georges Bank and western Scotian Shelf.

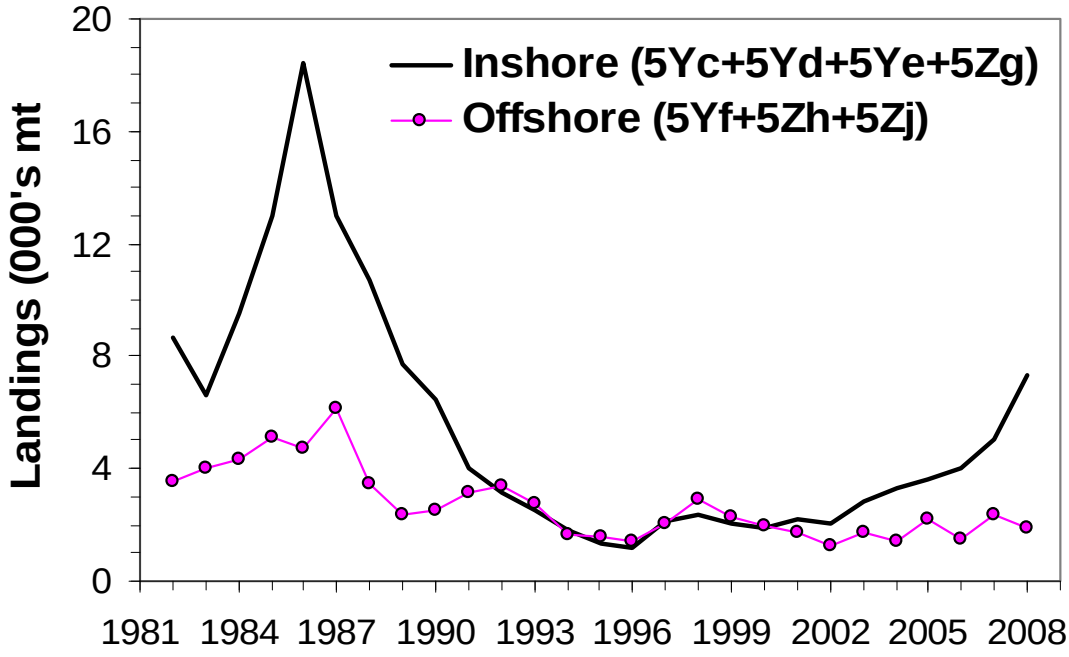

Figure 11. USA pollock landings from statistical unit areas combined to represent inshore (5Yc+5Yd+5Ye+5Zg) and offshore (5Yf+5Zh+5Zj) regions of the Gulf of Maine for 1982 to 2008.

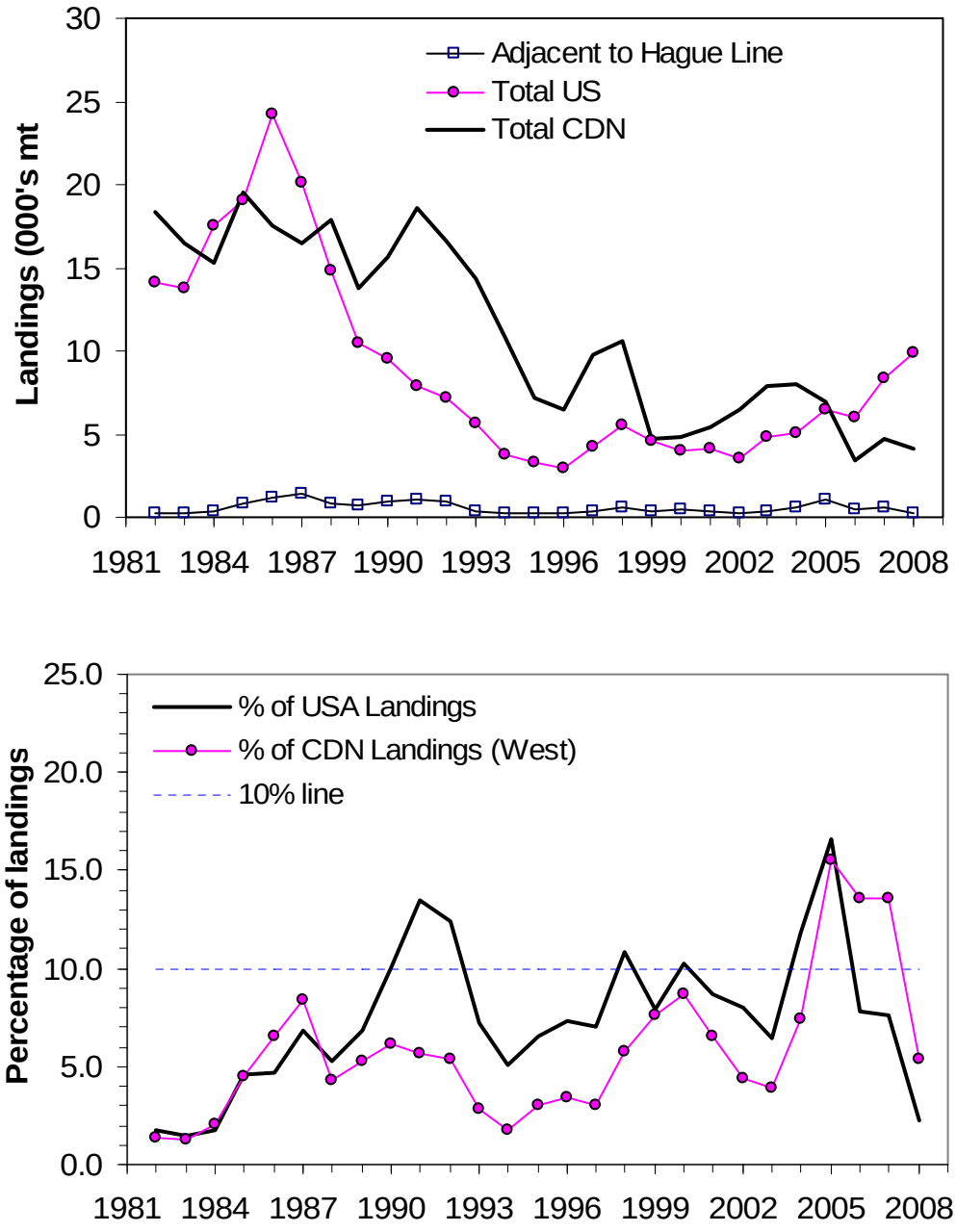

Figure 12. USA pollock landings from statistical unit areas adjacent to the Hague Line in the Gulf of Maine compared total Canadian (Western Component) and USA (SA 5&6) landings (upper panel).and expressed as a percentage of total Canadian and USA landings (lower panel) for 1982 to 2008.

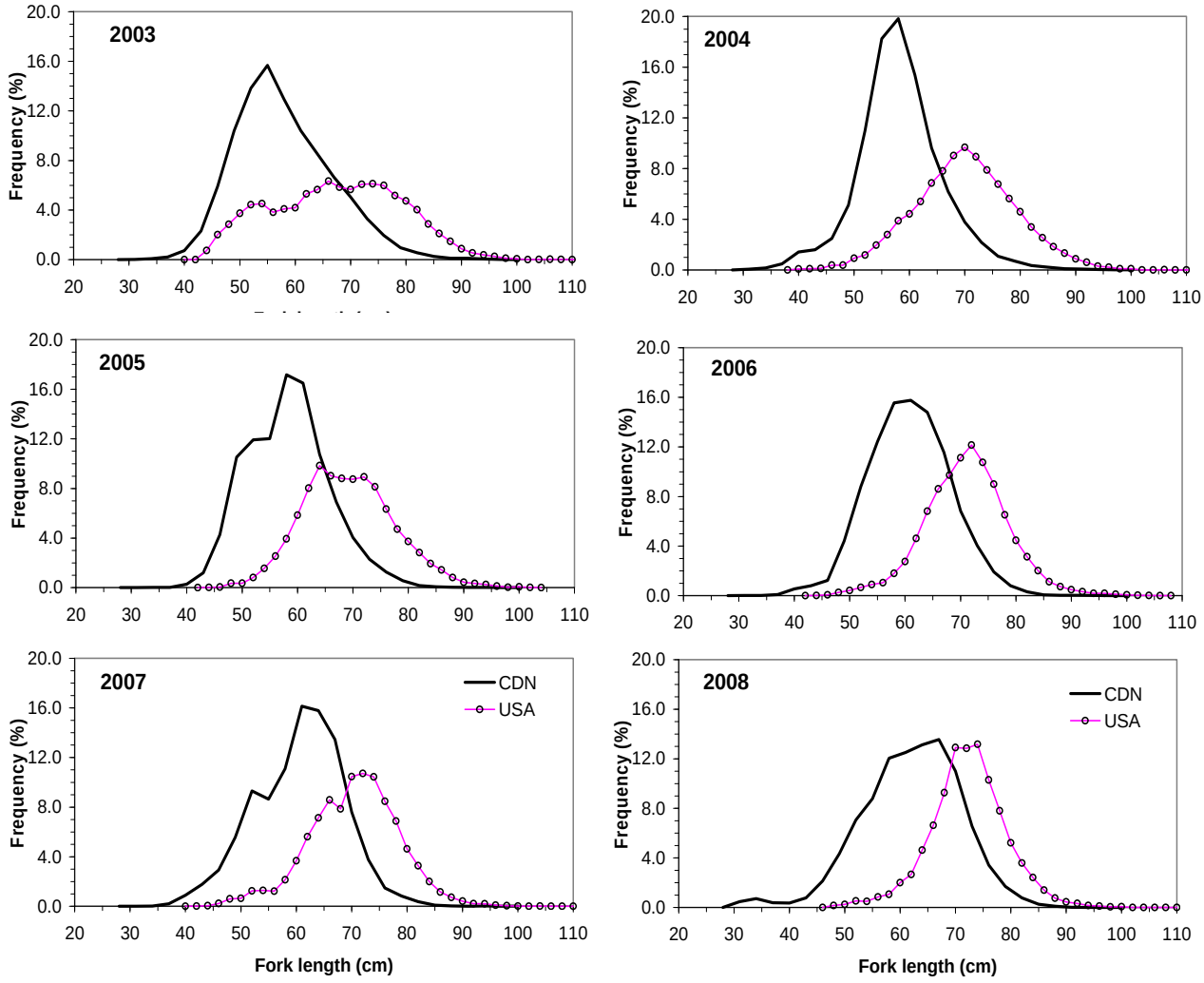

Figure 13. Pollock catch at size frequency (%) for Canadian (Western Component) and USA (SA 5&6) fisheries, all gears combined by year for 2003 to 2008.

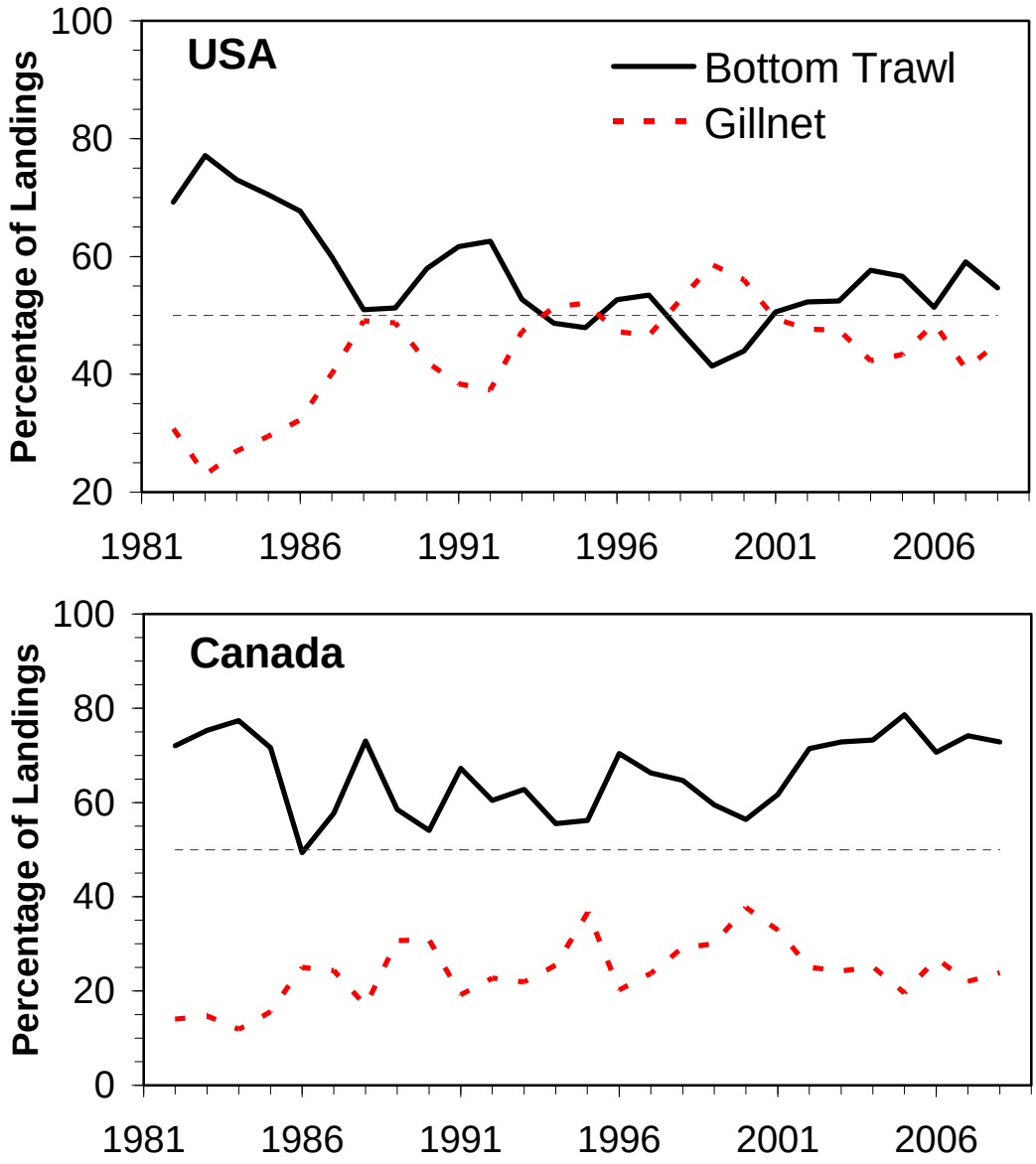

Figure 14. Percentage of total landings by gear type for USA (SA 5&6; upper panel) and Canada (Western Component; lower panel), from 1982 to 2008. Dashed line indicates 50% level.

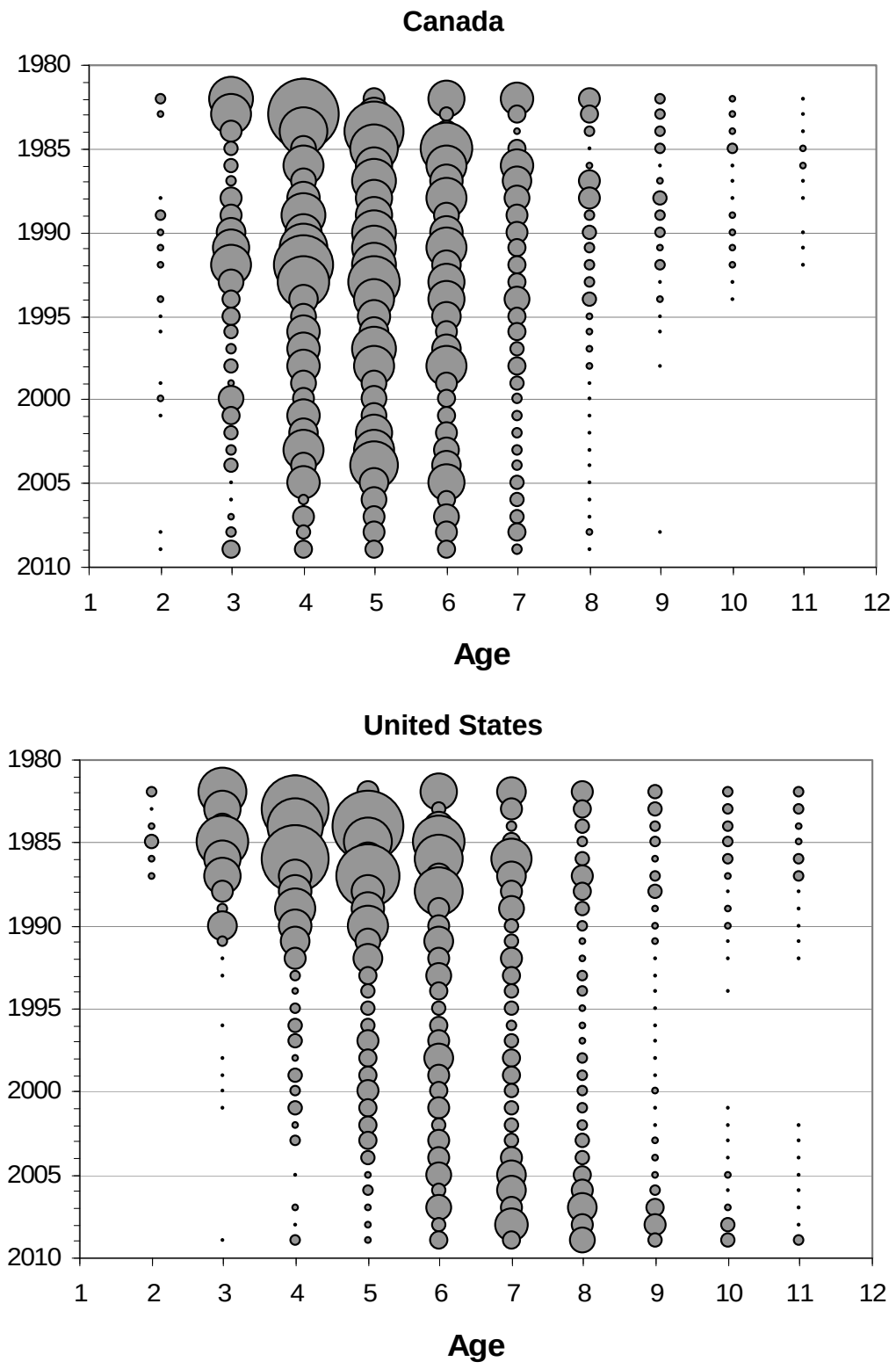

Figure 15. Age composition of the catch for Canada (Western Component; top panel) and the USA (SA 5&6; bottom panel) from 1982 to 2009. The area of the circle is proportional to the catch at age and year.

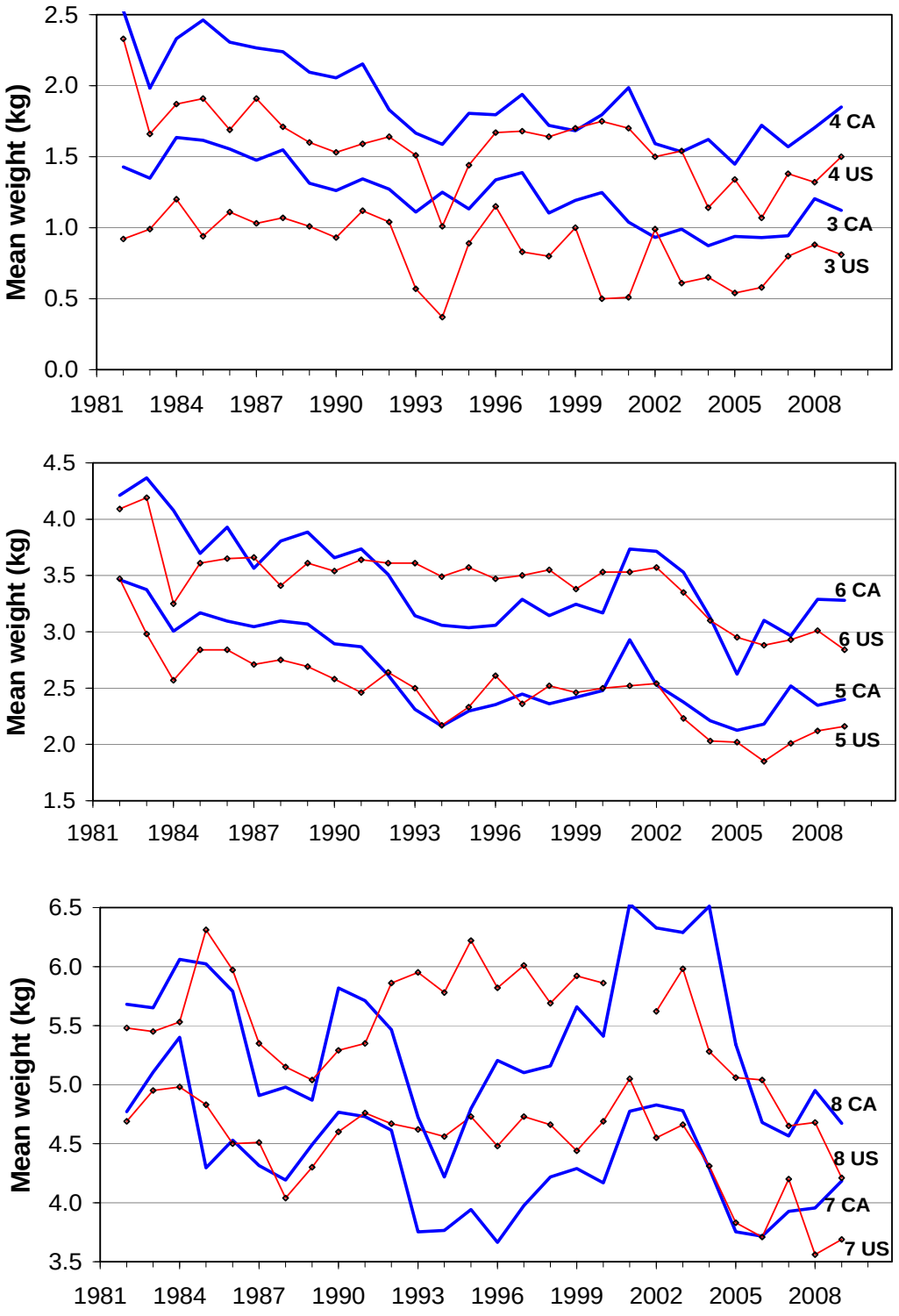

Figure 16. Trends in fishery weights at age for ages 3-8 for Canadian (Western Component) and USA (SA 5&6) fisheries from 1982 to 2009.

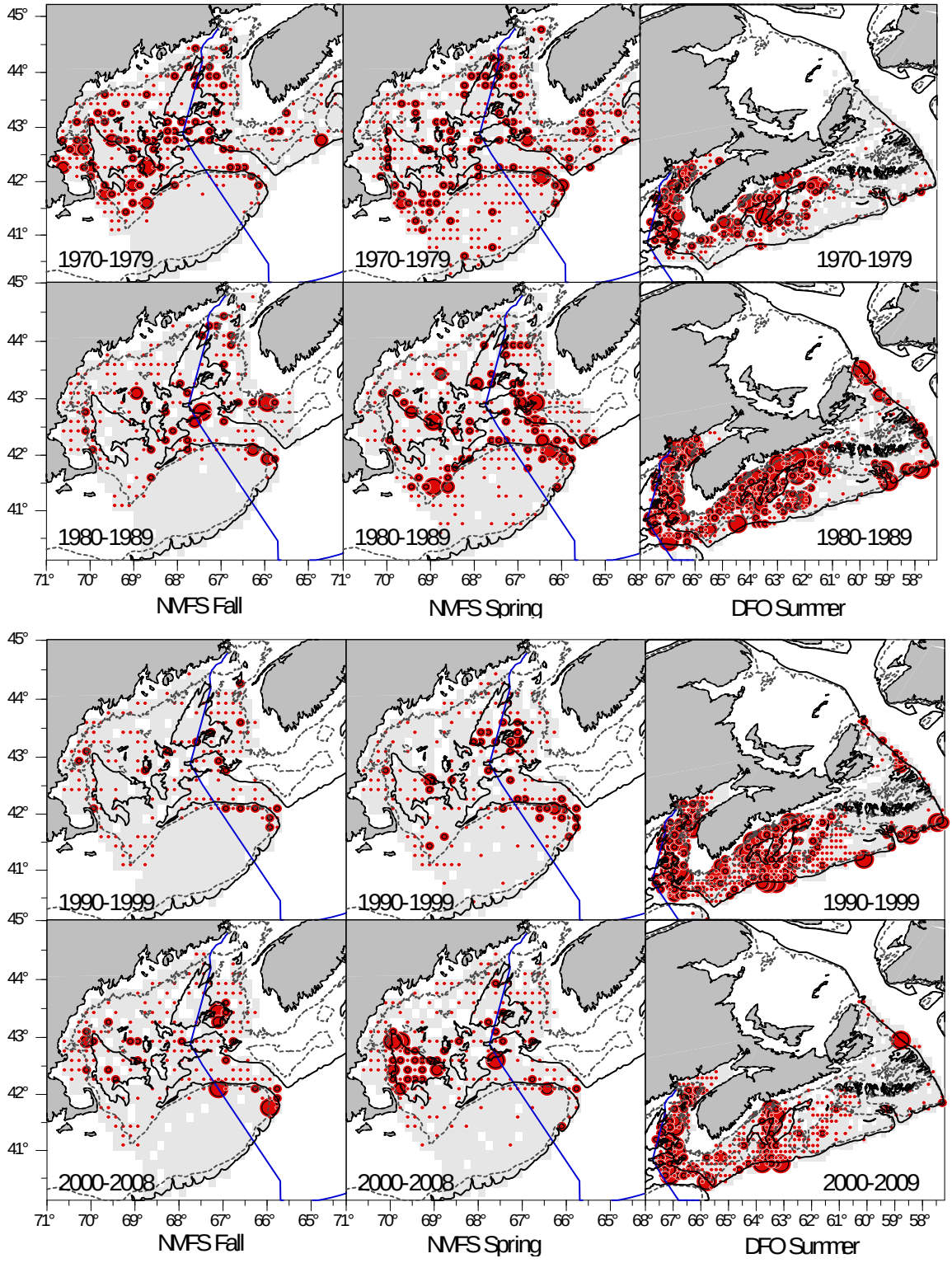

Figure 17. NMFS Fall, NMFS Spring and DFO summer survey biomass distribution (mean weight (kg)/10 min square) for surveys conducted in the 1970s, 1980s (top panel), 1990s and 2000s (bottom panel). Grey shading indicates areas surveyed with no pollock in the catch.

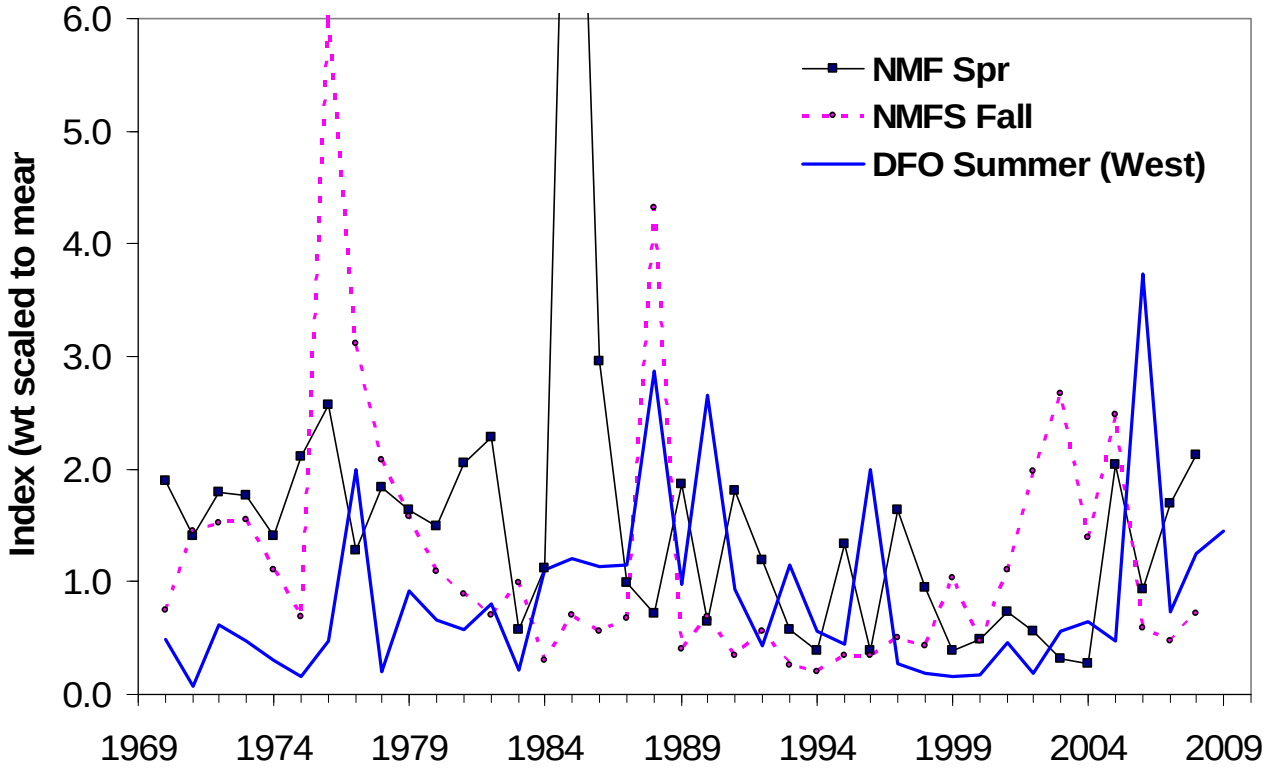

Figure 18. NMFS spring, NMFS fall and DFO summer (Western Component) survey biomass (kg/tow scaled to the mean for each series) for 1970 to 2009.

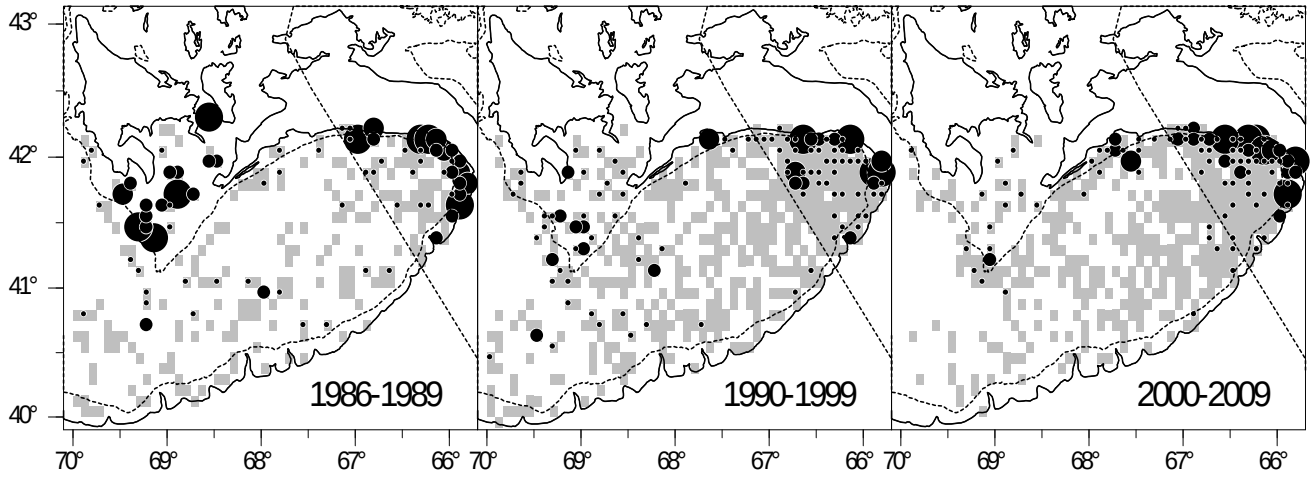

Figure 19. DFO RV survey biomass distribution (mean weight (kg)/10 minute square) for pollock on Georges Bank for surveys conducted in the 1980s, 1990s and 2000s. Grey shading indicates areas surveyed with no pollock in the catch.

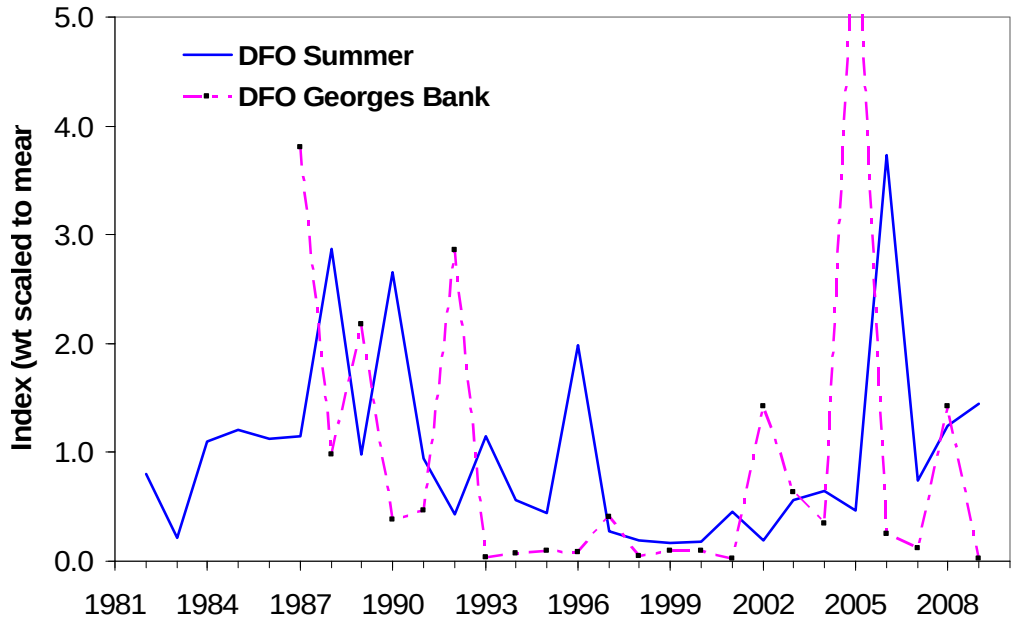

Figure 20. Comparison of trends in pollock biomass (kg/tow scaled to mean) from the DFO summer survey (1982-2009) and the DFO Georges Bank winter survey (1986-2009).

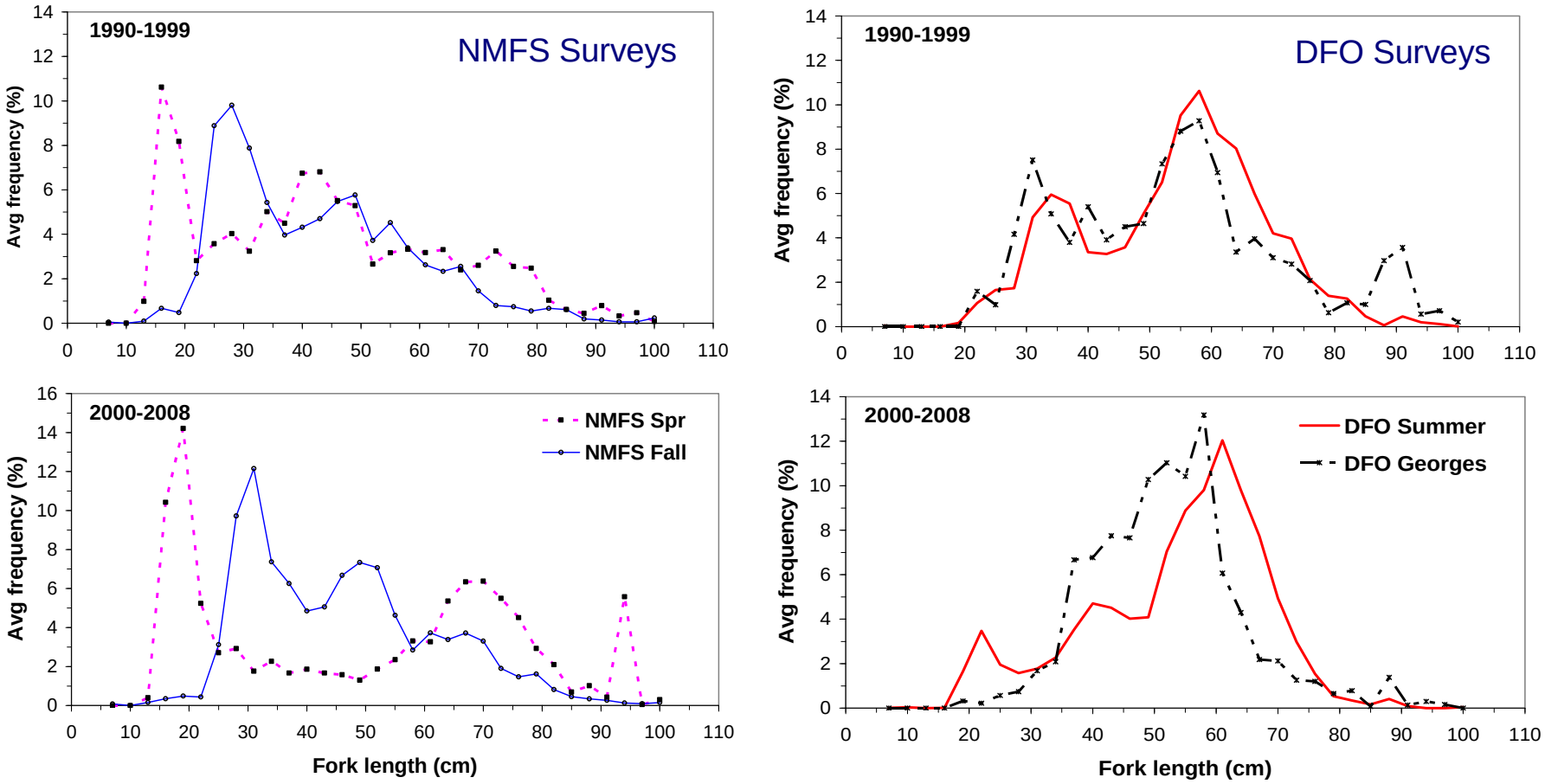

Figure 21. Average size frequencies (% at length) of pollock captured from NMFS spring and fall surveys in the Gulf of Maine and DFO surveys of western 4X and Georges Bank during the 1990s and 2000s.

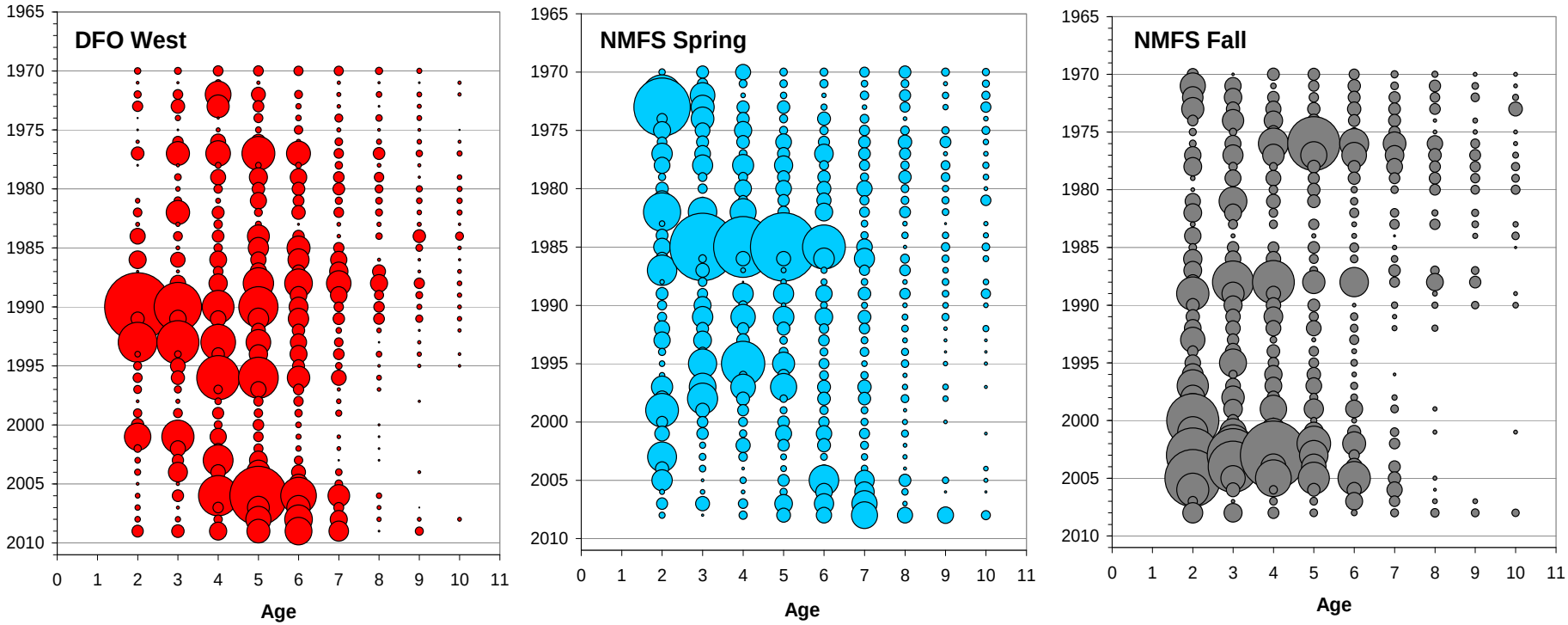

Figure 22. Stratified mean number per tow at age of pollock from the DFO summer (Western Component), NMFS spring and NMFS fall surveys from 1970-2008. The area of the circle is proportional to the catch at that age and year.

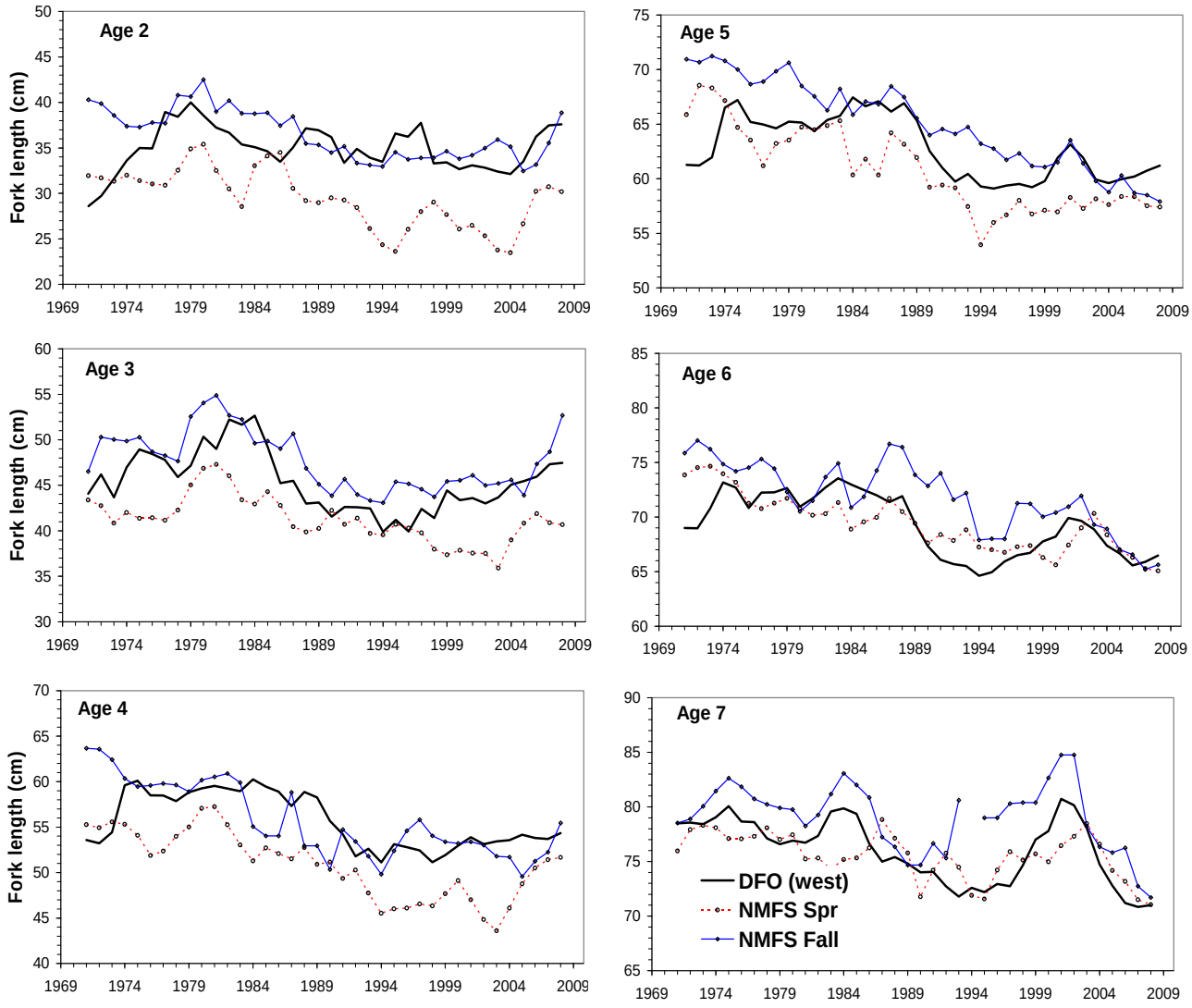

Figure 23. Average length at age (with a three year smooth) for pollock aged 2-7 for the NMFS spring, NMFS fall and DFO summer (Western Component) surveys from 1970-2008.

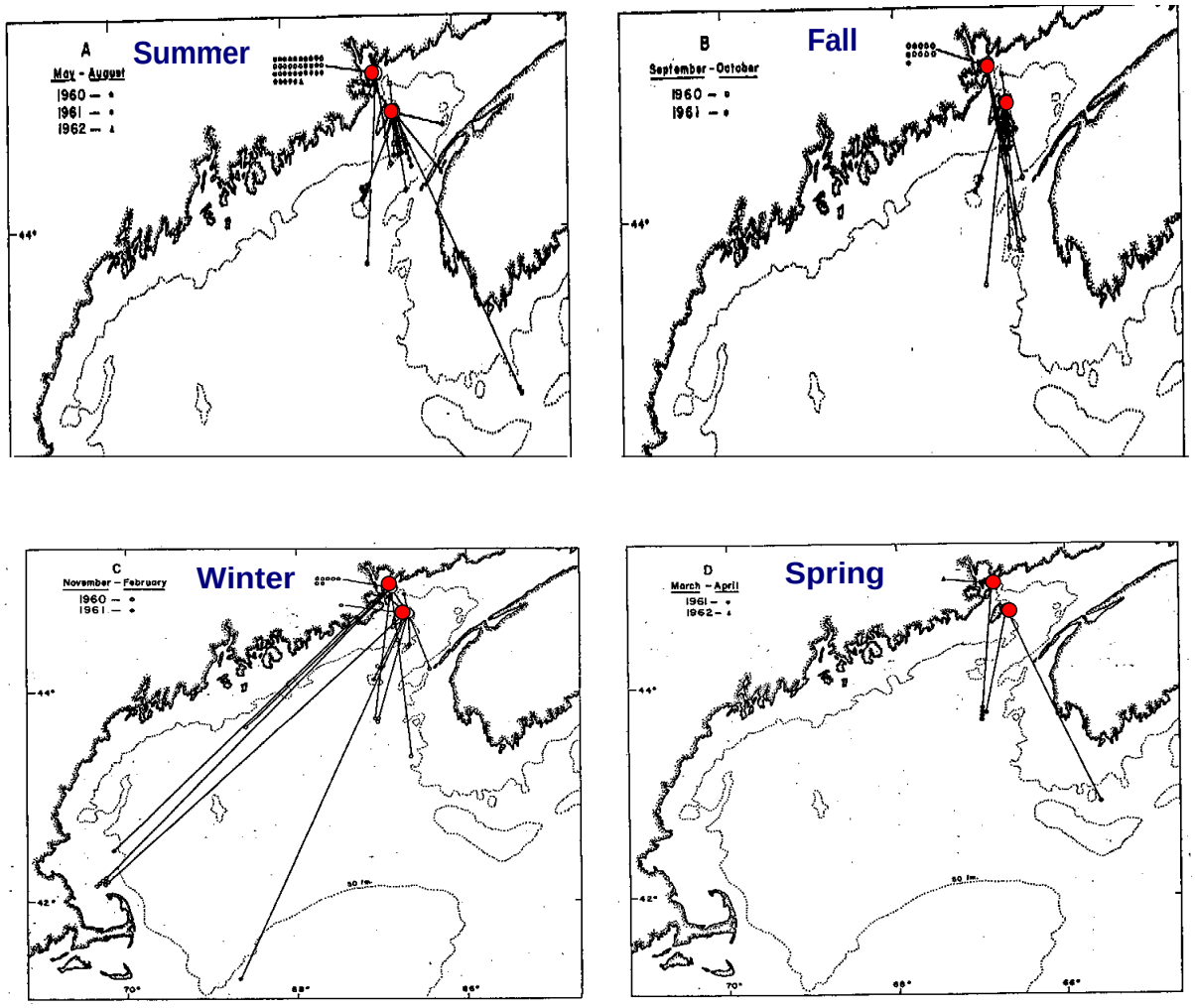

Figure 24. Seasonal locations of pollock recaptures from 1960-1963 that were originally released off Grand Manan and Campobello Islands (shaded circles) in 1960 (from Steele 1963).

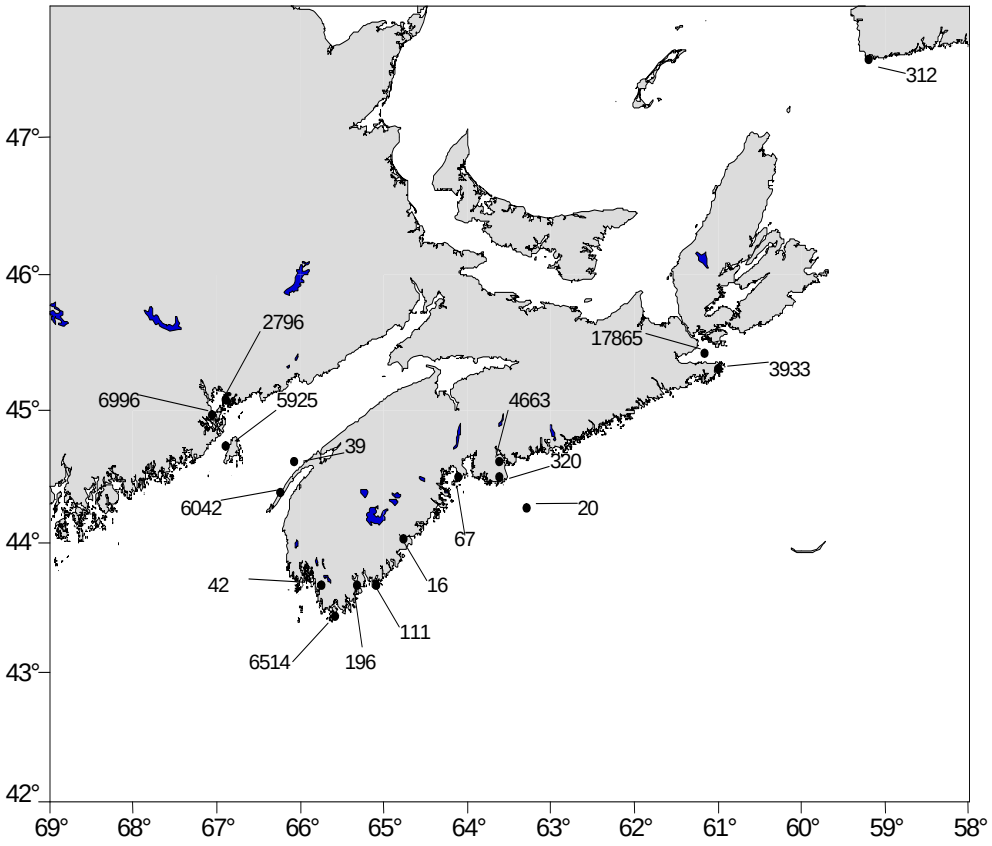

Figure 25. Sites of release and the numbers of marked pollock released at each site between 1978 and 1985 (from Clay et al. 1989).

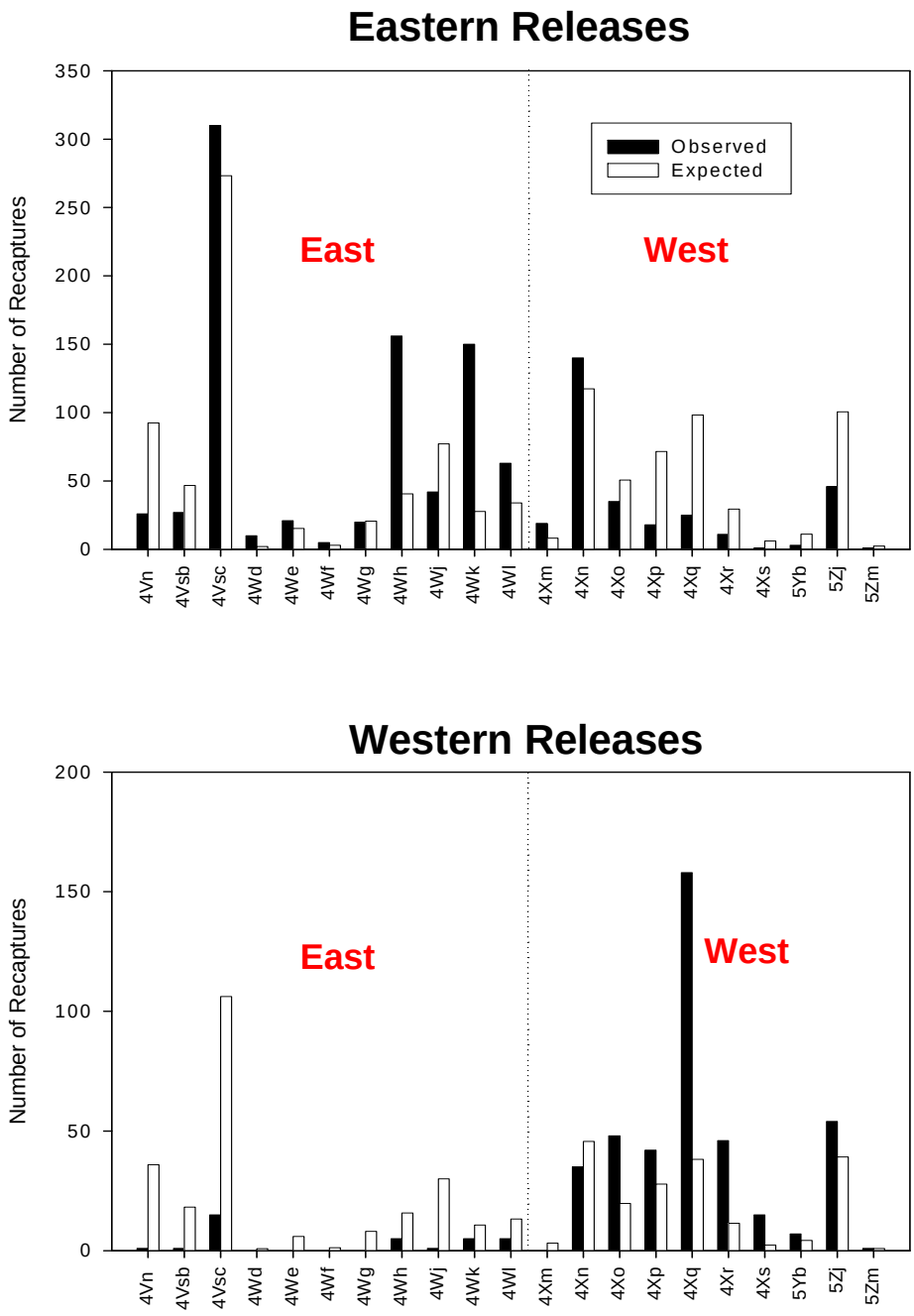

Figure 26. Distribution of observed and expected recaptures of pollock by the mobile gear fishery by Unit Area for fish released in the eastern and western sides of the management unit. The dotted line represents the boundary between eastern and western Unit Areas within the current 4VWX5 management unit. (from Neilson et al. 2006).

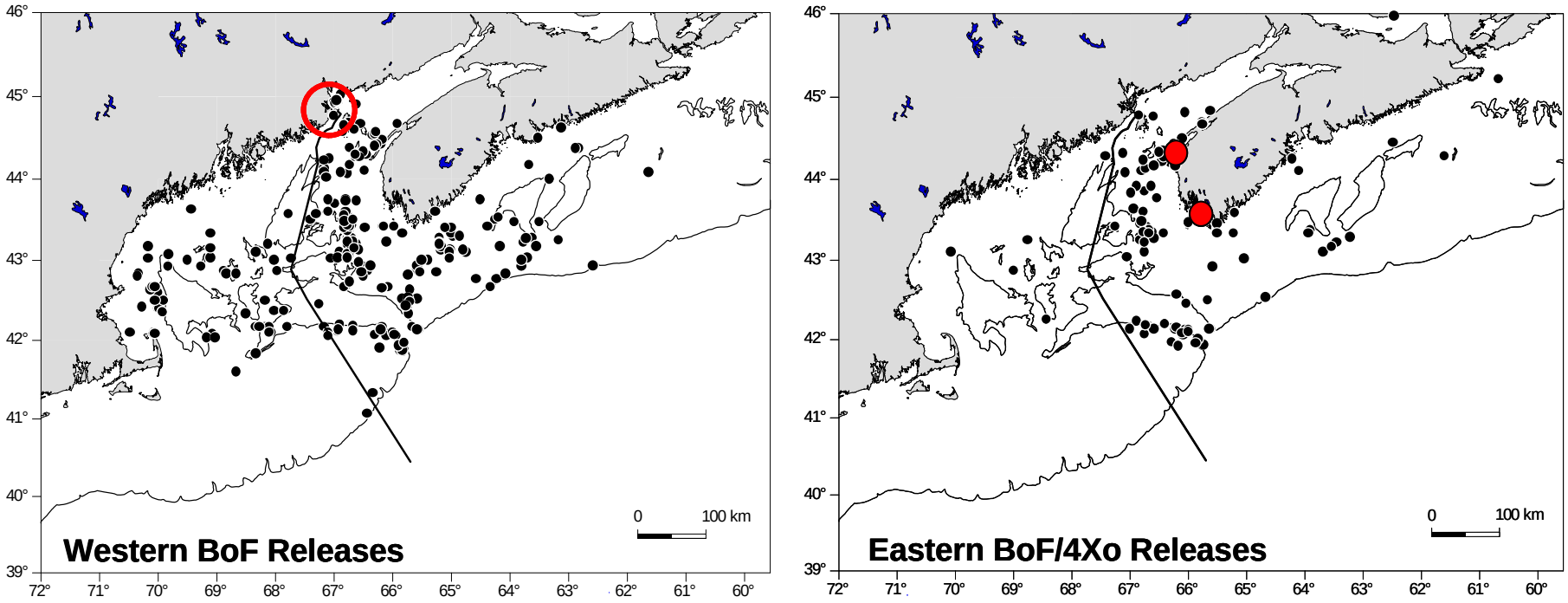

Figure 27. The location of releases (large open or shaded circles) and recaptures (small shaded circles) of marked pollock released on the western side of the Bay of Fundy (4Xs; left panel), the eastern side of the Bay of Fundy (4Xs; right panel) and off southwestern Nova Scotia (4Xo; right panel). (from Neilson et al. 2006).