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## 2008 Assessment of Pollock in 4VWX+5

## SCCS

Secrétariat canadien de consultation scientifique

## Évaluation de la goberge de 4VWX+5 en 2008

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#### Abstract

Fishery removals from the Western pollock stock component (4Xopqrs+5Yb+5Zc) averaged 6,000 t since 2000 and contributed $87 \%(3,469 \mathrm{t})$ and $81 \%(4,679 \mathrm{t})$ of total landings in 2006 and 2007, respectively. Assessment results were based on a Virtual Population Analysis (VPA) model for the Western Component that incorporated indices of abundance from both the summer research vessel (RV) survey (1984-2008) and standardized CPUE from the commercial fishery, excluding the most recent 4 years (1982-2004). Age 4+ (considered spawning stock) biomass has increased steadily from a low of $7,500 \mathrm{t}$ in 2000 to $29,000 \mathrm{t}$ in 2007, then declined to $27,000 \mathrm{t}$ in 2008. The 2001 year class was estimated to be slightly lower than indicated during the 2006 assessment ( 12.4 million versus 14.5 million recruits) and has been the strongest at age 2 since the 1988 year class. Current prospects for the 2004 and 2005 year classes are very poor (< 1.5 million recruits). Reduced quotas and harvests, as well as increasing population biomass have contributed to a decline in fishing mortality rates on ages $6-9$, which has been below the $F_{\text {ref }}$ of 0.2 since 2006. The range of harvest strategies in the 2009/2010 fishing year that are risk averse ( $25 \%$ risk of exceeding $\mathrm{F}_{\text {ref }}$ ) to risk neutral ( $50 \%$ risk of exceeding $F_{\text {ref }}$ ) are about $3,700 t$ to $4,400 t$, but are based on recruitment levels beyond the range of past model predictions (lower than previously observed for the time series). An alternate base model formulation was examined for projections and risk analyses which assigned the lowest observed value of age 2 recruitment for the VPA time series ( 3.4 million) for 2006-2008. Based on this scenario, the range of harvest strategies in the fishing year that are risk averse to risk neutral are about $4,100 \mathrm{t}$ to $4,750 \mathrm{t}$ for age $5+$. For the 2009/2010 fishing year, there is a $50 \%$ likelihood that removals of $4,500 \mathrm{t}$ would not allow for any increase in biomass, reflecting the absence of incoming recruitment. These harvest strategies are for 4 Xopqrs +5 Zc and would be conservative if applied to all of 4 X , since an additional 300-400 t of removals have occurred from 4 Xmn over the past 2 years.


Landings from the Eastern Component ( $4 \mathrm{Xmn}+4 \mathrm{VW}$ ) traditionally come from the Tonnage Class (TC) $4+$ sector, and have been following a declining trend, although they exceeded 1,100 t in 2007. Since 1993, much of the Eastern Component was closed to cod and haddock directed fishing, which further reduced pollock landings from that area. Summer RV survey biomass, while variable, has increased since 2006. Most of this increase is due to good catches in 4 Xmn , but not in 4 VW . Estimates of total mortality from the RV survey indicate a decrease in Z for 2006 and 2007 due to higher abundance in the 2007/2008 surveys; however, it is too early to tell if the situation is actually improving. While the current level of removals has allowed for some rebuilding of the Eastern Component (i.e. in 4 Xmn ), it is not rebuilt yet (i.e. 4V). Directed pollock fisheries for the east should proceed with caution.

With the exception of the 2007/2008 div. 4W test fisheries and, to a lesser extent, 5Z, observer coverage for pollock directed mobile gear fisheries is very low, and has been implemented largely to address management issues. Notwithstanding these limitations, most of the total catch (82-99\%) is landed and counted against respective quotas for these species. Dogfish appears to be the most commonly discarded bycatch species, with other species occurring at low levels. The highest amount of discarded catch appears to occur in the mobile gear fishery for redfish (4Xpq). Bycatch discards may also occur in the 4X pollock gillnet fishery, but observer coverage is far too low (i.e. 2 trips for 2006-2008) to make any conclusions. The habitat over which the directed pollock fishery takes place is highly energetic and of high complexity. The impact of the pollock fishery on the sea floor is currently unknown. The diet of pollock from the Scotian Shelf and Bay of Fundy has shown decadal changes, with euphausiids (krill) being predominant in the diet in the 1960s, less so in the 1990s, and once again since 2003.

## RÉSUMÉ

Les prélèvements de la pêche parmi la composante Ouest du stock de goberge (4Xopqrs+5Yb+5Zc) se sont situés en moyenne à 6000 t depuis 2000 et ils représentaient $87 \%$ ( 3469 t ) et $81 \%$ (4679t) des débarquements totaux de 2006 et 2007, respectivement. Les résultats de l'évaluation ont été fondés sur un modèle d'APV appliqué à la composante Ouest, qui intégrait des indices de l'abondance provenant du relevé par navire scientifique (relevé NS) réalisé l'été de 1984 à 2008 et des PUE normalisées de la pêche commerciale, à l'exclusion des quatre années les plus récentes (1982-2004). La biomasse des goberges des âges 4+ (considérées comme formant le stock de reproducteurs) a constamment augmenté après avoir connu un seuil de 7500 t en 2000, pour atteindre 29000 t en 2007; elle a ensuite diminué à 27000 t en 2008. La classe d'âge de 2001 a été jugée légèrement plus faible que ce qu'on avait estimé dans l'évaluation de 2006 ( 12,4 millions de recrues au lieu de 14,5 millions); elle a été la plus forte classe d'âge à l'âge 2 depuis celle de 1988. Les prévisions actuelles au sujet des classes d'âge de 2004 et 2005 sont très basses ( $<1,5$ million de recrues). La baisse des quotas et des captures ainsi que la hausse de la biomasse de la population ont contribué à une diminution du taux de mortalité par pêche parmi les âges 6 à 9 , ce taux étant été inférieur à la valeur $F_{\text {réf. }}$ de 0,2 depuis 2006. Les stratégies de capture pour l'année de pêche 2009-2010 qui présentent un risque allant de faible ( $25 \%$ de risque de dépassement de $\mathrm{F}_{\text {ref. }}$ ) à neutre ( $50 \%$ de risque de dépassement de Fréf.) $^{\text {. }}$ ) sont chiffrées à environ $3700 \mathrm{t}-4400 \mathrm{t}$, mais elles sont fondées sur des niveaux de recrutement supérieurs à des prédictions antérieures du modèle (qui étaient plus basses que les niveaux observés auparavant dans la série chronologique). Une autre formulation de modèle a été examinée en ce qui concerne les projections et analyses de risque associées à la plus basse valeur de recrutement à l'âge 2 observée dans la série chronologique fondée sur l'APV ( 3,4 millions) sur la période 2006-2008. Dans ce scénario, les stratégies de capture qui présentent un risque allant de faible à neutre pour l'année de pêche considérée sont chiffrées à environ $4100 \mathrm{t}-4750 \mathrm{t}$ pour les âges $5+$. Pour cette année de pêche 2009-2010, il y a $50 \%$ de probabilité que des prélèvements de 4500 t ne permettent pas de hausse de la biomasse, compte tenu de l'absence de nouveau recrutement. Ces stratégies de capture valent pour 4Xopqrs $+5 Z \mathrm{c}$ et elles seraient considérées comme prudentes si on les appliquait à la totalité de 4 X , étant donné que de 300 à 400 t supplémentaires ont été prélevés dans 4 Xmn au cours des deux dernières années.

Les débarquements en provenance de la composante Est ( $4 \mathrm{Xmn}+4 \mathrm{VW}$ ) ont jusqu'ici toujours émané de la flottille des navires de la catégorie de jauge $4+$ et ils ont suivi une tendance à la baisse, bien qu'ils aient dépassé 1100 t en 2007. Depuis 1993, une bonne partie de la composante Est est fermée à la pêche dirigée de la morue et de l'aiglefin, ce qui a contribué à réduire davantage les débarquements de goberge en provenance de ces eaux. La biomasse d'après le relevé NS d'été, quoique variable, a augmenté depuis 2006. La majeure partie de cette hausse est due à de bonnes prises dans 4 Xmn , mais non dans 4 VW . Les estimations de la mortalité totale d'après le relevé NS dénotent une baisse de Z en 2006 et 2007, reflétée dans la plus forte abondance observée dans les relevés de 2007-2008, mais il est trop tôt pour savoir s'il y a là une réelle amélioration de la situation. Bien que le niveau actuel de prélèvements ait permis un certain rétablissement de la composante Est (dans 4 Xmn ), celle-ci ne s'est pas encore reconstituée, comme le montre la situation dans 4 V . Les pêches dirigées de la goberge dans la composante Est devraient donc être guidées par la prudence.

Sauf en ce qui concerne les pêches d'essai pratiquées en 2007-2008 dans 4W et, dans une moindre mesure, dans $5 Z$, très peu d'observateurs sont présents dans les pêches dirigées de la goberge aux engins mobiles et ceux qui sont embarqués le sont dans une large mesure pour régler des problèmes de gestion. Malgré cette insuffisance, la plupart des prises totales (de 82 à $99 \%$ ) sont débarquées et défalquées des quotas respectifs des espèces capturées. Les rejets les plus courants semblent être ceux qui vivent les prises accessoires d'aiguillat, les rejets d'autres espèces étant faibles. C'est dans la pêche du sébaste aux engins mobiles (dans 4 Xpq ) que les rejets de prises semblent être les plus élevés. Il se peut que des prises accessoires soient aussi rejetées dans la pêche de la goberge au filet maillant dans 4 X , mais la présence d'observateurs dans cette pêche est
bien trop insuffisante (n'ayant porté que sur deux sorties de 2006 à 2008) pour qu'on puisse tirer quelque conclusion que ce soit. L'habitat des fonds sur lesquels se déroule la pêche dirigée de la goberge se caractérise par une grande énergie et une vaste complexité. On ne sait pas actuellement quelle est l'incidence de la pêche sur le fond marin. Le régime alimentaire de la goberge sur le plateau néo-écossais et dans la baie de Fundy a changé au fil des décennies; les euphausiacés (le krill) y occupaient une place prépondérante dans les années 1960, moindre dans les années 1990 et dominante à nouveau depuis 2003.

## INTRODUCTION

Pollock in the management unit (Northwest Atlantic Fisheries Organization (NAFO) divisions) $4 \mathrm{VWX}+5$ are assessed as Western (4Xopqrs+5Yb+5Zc) and Eastern components ( $4 \mathrm{VW}+4 \mathrm{Xmn}$ ), following the recommendations of the framework assessment completed in 2004 (Neilson et al. 2004) (Fig. 1). This Research Document updates the last stock assessment for pollock in the Western Component completed by Stone et al. (2006), and includes updated information for 2006 (fishery data: Trimester 3), 2007 (survey and fishery data: Trimesters 1-3) and 2008 (survey and fishery data: Trimesters 1-2).

Advice was requested by Department of Fisheries and Oceans (DFO) Fisheries and Aquaculture Management Branch on the stock status of pollock to inform management of the 2009/2010 fishery. The Terms of Reference for this Science Advisory Process peer review were to:

- Review and evaluate biological and fishery information on $4 \mathrm{VWX}+5$ pollock stock status to be used as the basis for establishing the Total Allowable Catch (TAC) for the 2009/2010 fishery.
- Update the advice using the 2004 assessment framework and the latest information from fisheries and research surveys.
- Evaluate the impact of pollock and the pollock fishery in an ecosystem context, including:
o Descriptions of bycatches.
o Comment on possible benthic impacts.
o Update information on pollock predator/prey interactions.


## THE FISHERY

Landings of pollock for the Western Component of the management unit (4Xopqrs+5Yb+5Zc) in fishing years ending 31 March 2007, and 31 March 2008, were 3,768 t and 4,411 t, respectively, against quotas of $4,500 \mathrm{t}$ and $5,000 \mathrm{t}$ (Fig. 2). Landings from the west for 2008 are currently at $3,332 \mathrm{t}$ (Apr.-Dec., quota $=5,000 \mathrm{t}$ ). Calendar year landings were used for the analytical assessment and for 2006, 2007, and 2008 were $3,965 \mathrm{t}, 5,799 \mathrm{t}$, and $4,096 \mathrm{t}$ (Jan.-Aug.), respectively (Table 1). Landings from Eastern Component (4VW+4Xmn) represented over half the catch up to 1990, but have declined significantly, and in 2003 dropped to 243 t . In the fall of 2007 and 2008, the mobile gear sector was allowed to participate in a test fishery in 4Vs and 4 W , which resulted in landings of 586 t and 373 t , respectively. Overall, the TAC has rarely been restrictive except for a 5 year period in the late 1980s and, more recently, since 2004 (Fig. 2).

The pollock fishery has had significant changes in both area fished and in dominant gear type. The Western Component of the management unit usually contributes the largest proportion of the total landings (> 80\% since 2000) (Fig. 3, Table 2). Landings from the Eastern Component traditionally came from the TC 4+ sector, and have followed a declining trend since 1990 (Fig. 3; Table 3). Since 1993, much of the Eastern Component has been closed to cod and haddock directed fishing, which further reduced pollock landings from that area. Landings from the Western Component now come mostly from unit areas 4 Xpq , and have declined substantially from the Bay of Fundy ( $4 \mathrm{Xrs}+5 \mathrm{Yb}$ ) and Georges Bank ( 5 Zc ) since 2003 and 2004, respectively, and off southwest Nova Scotia (4Xo) since the mid 1990s (Fig. 4; Table 2). The seasonal pattern of the fishery over the past 3 years for the west was similar to previous years, with most pollock catches occurring from May through September (Table 4). Occasionally, winter fisheries have occurred with high landings in January and February (i.e. 1986-1988, 1991, 1993, and 2005).

The mobile gear fishery (OTB (otter trawl bottom) 1-3) in 2007 and 2008, occurred mainly in Crowell and Jordan basins (4Xpq), northeastern Georges Bank (5Zc), the outer Bay of Fundy (4Xrs), along shelf slope, and east of LaHave Bank (4Xn) (Fig. 5). During the fall of 2007 and 2008, there was a test fishery in 4W, which occurred in Emerald Basin and along the shelf slope south of Emerald Bank. Gillnet catches for 2007-2008 were mainly from the Jordan Basin area (4Xq), although there were also catches from northeastern Georges Bank (5Zc), Baccaro and LaHave banks (4Xn), and around the edges of LaHave (4Xm) and Emerald basins (4Wkl) (Fig. 6). Generally, the gillnet fishery had a similar spatial distribution for both years. As indicated by Neilson and Perley (2005), the overall distribution of catches in recent years has contracted since the early 1990s.

Since the early 1980s, the small mobile gear component (OTB 1-3) has accounted for most of the total landings, followed by gillnet (Fig. 7; Table 5). The percentage of total landings taken by gillnets has declined since 2000, while the small mobile share has increased. Currently, the gillnet share is $22 \%$ and small mobile is $75 \%$; however, both gear sectors are also limited by their respective quotas. The contribution of larger trawlers to total landings (OTB 4+) has been steadily declining since the mid 1990s, but showed a modest increase from $2 \%$ in 2005 to $6 \%$ in 2006. The offshore sector was using smaller vessels (TC 1-3, under the Temporary Vessel Replacement Program (TVRP)) to catch their allocation. The TVRP category is currently no longer in existence as a quota group for pollock (as of the 2008-2009 fishing year), and there have been no TC 4+ vessels involved in the fishery since 2007. The contribution by the longline/handline sector has also declined since the mid 1990s, but there has been a modest increase ( $3 \%$ of total landings) over the past few years.

## Industry Perspectives

A data input review meeting was held in Bridgewater, Nova Scotia, on 21 October 2008, during which the fishing industry made several comments about the 2007-2008 pollock fishery. The main points are summarized below:

- With the low quota, pollock is essentially a bycatch, and fixed gear fishers try to make their allocations last as long as possible throughout the year. Since it has been difficult to avoid pollock in the past few years, gillnet fishers have been using up their allocations relatively quickly, even when trying to fish areas where they can catch more cod rather than pollock. One gillnet fisher reported that catches of pollock on Georges Bank are very good, even when using 7" mesh. Unlike the past, it is now difficult to avoid them and they can be caught outside of the traditional "deep water" fishing area on the bank.
- For the past 2 years, the longline sector has been experiencing catch rates similar to the 1980s. Longline fishers are seeing good catch rates in their fishery and are concerned about catching too much pollock all at once.
- Some mobile gear vessels have not been directing for pollock, but may make a few sets near the end of a trip to "round" it out. The 2007 and 2008 catch rates were not considered to be representative of abundance.
- The July research vessel (RV) survey does not cover the entire geographic area of the pollock fishery. Georges Bank is not sampled at all during the summer survey, a time when mobile and fixed gear vessels are catching pollock on the bank. Since 2000, landings from $5 Z$ c have represented $20 \%$ of the total catch. The RV survey does not include this biomass.
- Industry feels that there is as much pollock now as there was back in the "heyday". In their opinion, a quota of $10,000 t$ is sustainable.
- One participant representing the offshore sector (which holds $50 \%$ of the pollock quota) expressed concern about a joint assessment and TAC agreement with the US and indicated that they would not be in favour of this approach.


## SAMPLING AND CATCH/WEIGHT AT AGE

Port (shore) and observer (at-sea) sample collections contributed to several thousand pollock length measurements annually from 2006-2008 (Table 6). Sampling was considered adequate to characterize the catch at size and catch at age (CAA) for the Western Component, with 1,111 and 1,649 ages available for the 2006 and 2007 fisheries, respectively, and 1,194 ages available to the end of the second trimester in 2008. Length and age data was also available for mobile gear fisheries in the Eastern Component (i.e. in 4Xmn and 4W) for 2007 and 2008, but not for fixed gear fisheries (which may land over 200 t annually). This difference occurs because there is currently no commercial port sampling available east of Shelburne, Nova Scotia. Fixed gear vessels fishing in the Eastern Component that land their catches east of Shelburne would not be sampled; however, mobile gear vessels fishing in the east often land their catches in southwest Nova Scotia ports and, therefore, may be sampled.

Comparisons of 2007 and 2008 port and observer length measurements of pollock from the directed fishery were made for months, areas, and gear types, where both types of samples were available. For the most part, these comparisons showed similar catch size frequencies of pollock. An exception was 5Zj in 2008, but observer sampling for this area was low (Fig. 8). Pollock are also captured in the small mesh (cod end mesh < 130 mm ) 4Xpq redfish fishery. Comparisons of 2008 port and observer length measurements generally indicated different size compositions of pollock, with small fish ( $30-40 \mathrm{~cm}$ ) observed at-sea, but not in port sample collections (Fig. 9, upper panel). This difference may indicate high-grading or discarding of small pollock from the 2008 redfish fishery. If this is the case, then the CAA for smaller, younger pollock would be underestimated. Vessels directing for redfish should leave the Crowell/Jordan Basin area (Fig. 9, lower panel) when catch rates of small pollock (i.e. $<40 \mathrm{~cm}$ ) are high.

The level of commercial fishery sampling was relatively low in the 1970s in 4X; thus, the assessment presented here starts in 1982, when the level of sampling improved to reflect the fishery more accurately. To construct the catch at age for 2008 (Trimesters 1 and 2), 2007 (Trimesters 1-3), and to update the CAA for 2006 (with data from Trimester 3), data for the Western Component was aggregated to the trimester level by gear type and tonnage class. Area 4Xu was prorated over the Western Component by allocating the proportion of landings attributed to 4 Xmn versus the remaining unit areas in 4X. Samples were aggregated on a trimester basis for all gear sectors (OTB 1-3 large mesh (cod end mesh $\geq 130 \mathrm{~mm}$ ), OTB 1-3 small mesh (cod end mesh < 130 mm ), gillnet, OTB 4+, and longline/handline gear). Small pollock are caught in the small mesh mobile gear used in the 4Xpq redfish fishery, so this gear type was kept separate in the CAA. Length-weight parameters were calculated from data pooled over the last 10 years from the summer RV survey for stratas 474, 476, and 480-495 (the Western Component). Since no surveys were conducted in the spring or fall, the summer value is used for all 3 trimesters.

In order to evaluate the consistency of age determinations, the primary ager for the $4 \mathrm{VWX}+5$ pollock stock re-aged otolith sections used during a Canada/US ageing workshop in 2001. Agreement with prior Canada/US consensus ages was 92\% (Between Ager Comparison, Fig. 10). In a second comparison using otolith sections from the 2007 Canadian fishery, the
primary ager conducted self testing (Within Ager Comparison, Fig. 10), which yielded 89\% agreement. Based on these comparisons, it was concluded that current pollock age interpretations are consistent and have no appreciable bias.

Larger pollock were captured by gillnet and handline/longline (average: 65-67 cm fork length (FL)) compared to large mesh mobile gear (average: 58-61 cm FL) (Fig. 11, upper panel). The small mesh mobile gear (used in the 4Xpq redfish fishery) captured a greater proportion of pollock < 46 cm FL, especially in 2008. The age composition of the catch differed among gear types, ranging from 5-8 for gillnet and handline/longline, 3-7 for large mesh mobile, and 2-7 for small mesh mobile gear (Fig. 11, lower panel).

Strong and weak year classes are apparent in the age structure, and cohorts are readily tracked (Table 7; Fig. 12). Diminished numbers at age for older ages, a feature which first appeared in the 1990s, continues to the present. The 2008 fishery is dominated by ages 5,6 , and 7 ; the 2003, 2002, and 2001 year classes, respectively. The most recent strong year classes apparent in the fishery are the 1999 year class (white circles) and the 2001 year class (yellow circles). Both have made significant contributions to the Western Component fishery over the past 4 years, and the 2001 year class continues to be important at age 7 in 2008.

In general, fishery weights at age (WAA) have been decreasing since the early 1980s, but seem to be levelling off or increasing now (Table 8; Fig. 13). In 2008, there was slight increase in WAA for ages 3,4 , and 6 , and slight decrease for ages 5 and 7 .

## INDICES OF ABUNDANCE

## Commercial Fishery Catch Rates

Commercial fishery catch rates (CPUE) for small mobile gear (TC 1-3) are used as tuning indices in this assessment, and are based on individual standardized catch rates from 4 areas in the Western Component: $4 \mathrm{Xq}, 4 \mathrm{Xp} / 5 \mathrm{Zc}$, Bay of Fundy ( 4 Xrs and 5 Yb ), and 4 Xo . The main criteria for trips included in catch rate analyses is that they must be pollock directed (> $50 \%$ of total catch is pollock) and the vessel must have 5 or more consecutive years in the fishery. A multiplicative model (Gavaris 1980, 1988a) with main effects of year (1982-2008), CFV number, month, and cod end mesh type (diamond or square) was solved using standard linear regression techniques after In transformation of nominal CPUE (t/hr) data:
$\ln \left(\right.$ CPUE $\left._{\mathrm{ijk})}\right)=\mu+$ Year $_{\mathrm{i}}+$ Month $_{\mathrm{j}}+$ Vessel $_{\mathrm{k}}+$ Mesh Type $_{\mathrm{l}}+\mathrm{e}_{\mathrm{ijk} \mid}$
Analysis of variance results indicated that for each area, the overall regression and individual main effects were significant ( $P<0.5$ ), and that the model explained between $36-49 \%$ (multiple $r^{2}$ ) of the variability in the data. A weighting factor was applied to the standardized catch rates for each of the 4 areas to account for changes in the spatial distribution of fishing activity (after Walters 2003), then they were averaged together to generate a single index for the Western Component. The weighting factor for each area was calculated as the number of productive 10' squares in that area in 1992 (a year of high landings) divided by the total number of productive 10' squares in all areas in 1992.

There has been a general declining trend in standardized catch rates for all areas since the early 1980s, followed by an increase after 2001 (Fig. 14, upper panel). Area $4 \mathrm{Xp} / 5 \mathrm{Zc}$ has had the highest catch rates since 2001, reaching a peak in 2007 before declining in 2008. Catch rates for 4 Xq , the next highest area, declined between 2003 and 2006, but have increased
sharply since then; while for the Bay of Fundy, catch rates have been declining since 2003. Area 4Xo has had very few trips since 1997, so this series has been set to "0" in the CPUE index from 1998 to present. The area-weighted CPUE for all areas combined reached the second lowest level in the time series in 2006, with the lowest occurring in 1998 (Fig. 14, lower panel). Since 2006, catch rates have been higher but variable. Catch rates from 2005 to 2008 were constrained by reduced quotas and changes in fishing practices and are not comparable to those earlier in the time series. The current view is that since 2004, this series may no longer reflect trends in relative abundance.

The age-specific indices of abundance from the mobile gear sector of the fishery indicate a reduction in the abundance of older (ages 7+) fish since 1996, with modest signs of improvement in age structure beginning in 2006 (Table 9; Fig. 15). The 1999 year class is noteworthy from 2003-2007 and continues to be present at age 9 in 2008. The 2001 year class is predominant in 2007 at age 6 and in 2008 at age 7. Both the 2004 and 2005 year classes at age 3 look stronger than the previous 2 year classes at this age.

## DFO Research Vessel (RV) Survey

Indices from the summer DFO research vessel survey based on $4 X$ strata 474,476 , and $480-$ 495, are used in the assessment of the Western Stock Component. The time series begins in 1984, the first year that the RV Alfred Needler was used for the summer survey program. The 2006 summer survey biomass index was at the highest observed level in the time series and, although this was an obvious year effect, there has been a general increasing trend since 2002, which persists through to 2008 (Fig. 16). Strong year-effects are present in other years as well (i.e. $1988,1990,1996$ ) and reflect the semi-pelagic schooling behaviour of pollock and changes in $q$. In 2007 and 2008, several good catches occurred in the Western Component area off southwestern Nova Scotia (4Xpq) (Fig. 17). There were also good catches in the Eastern Component along the Shelf edge, and around LaHave Basin ( 4 Xmn ). However, with the exception of 2 good sets along the Laurentian Channel in 2007, survey catches in the central $(4 \mathrm{~W})$ and eastern (4V) shelf area were quite low.

Consistent with the catch rate information, the DFO RV indices for the Western Component show that the 1999 year class appears strong from 2003 to 2007; however, not many are left by age 8 in 2008 (Table 10; Fig. 18). The 2003 year class (age 5) and the 2002 year class (age 6) are predominant in 2008, and the 2001 year class at age 7 is also noteworthy. More older fish are present now than in the past (i.e. ages 7 and 8), but incoming recruitment (i.e. 2004 and 2005 year classes at age 3) appears to be weak. The record high indices at all ages in 2006 should be interpreted with caution, since indices for all year classes are inconsistent with values seen previously.

RV survey weights at age (equivalent to mid-year population WAA) follow a declining trend from the early 1980s to late 1990s (Fig. 19). Since the late 1990s, WAA has been increasing for ages 2-5, but declining for ages 6 and 7, until this year. In the 2006 assessment, there was some concern that survey weights at age did not appear to have the same declining trend evident in the fishery weights at age for age 5+ (Fig. 13), and that fishery WAA may be influenced by changes in fishing patterns. Since 2006, the fishery WAA has increased for most age groups, so this difference may no longer be an issue.

## Other Survey Indicators

The Individual Transferable Quotas (ITQ) survey is not used as a tuning index, but it provides qualitative information to compare with the DFO summer survey. In 2007 and 2008, there were very low catches of pollock compared to the 10-year average. Only 2 tows with good catches occurred in 2008 in 4Xpq, with very low catches in 4Xmn compared to 2007 (Fig 20). Trends in biomass between the DFO summer survey, the CPUE series, and the ITQ survey show some concurrence; however, the ITQ survey tends to be much more variable than the other 2, and shows a strong decline after 2006 to low levels in 2007 and 2008 (Fig. 21). This is inconsistent with the DFO survey and CPUE series for the recent period; therefore, the ITQ series may not be that useful for trend comparisons.

The National Marine Fisheries Service (NMFS) has conducted stratified random surveys during spring and fall in the Gulf of Maine since the 1960s. The 2008 NMFS spring survey shows good catches in the western Gulf of Maine and northeastern Georges Bank; however, the 2007 NMFS fall survey had low catches in the western Gulf of Maine and no catches on Georges Bank (Fig. 22). There was only one good set from this survey, which occurred in Jordan Basin. The 5 year average for both series indicates that catches occur across international boundary and that there is continuity with the Western Component in 4 X . The NMFS fall survey biomass index shows a general trend of increasing pollock biomass in the Gulf of Maine from 2001 through 2005, but it drops off in 2006 and 2007 (Fig. 23). The NMFS spring series is contrary, and indicates that biomass has been increasing in recent years and supports recent biomass trends observed in the DFO survey. The most recent NMFS assessment for the Gulf of Maine (sub-areas 5 and 6) pollock stock conducted in 2008 (based on catch statistics and fall survey biomass series) suggests that this stock is overfished and that overfishing is occurring.

## ESTIMATION OF CURRENT POPULATION STATE

Two VPA runs were conducted using the framework assessment formulation of Neilson et al. (2004), with a few modifications. The Base Model formulation (accepted for the 2006 assessment) used CAA for ages 2-13 (1982-2008), RV indices for ages 3-8 (1984-2008, proportional fit), truncated CPUE indices for ages 3-8 (1982-2004, power fit), and natural mortality of 0.2. The truncated CPUE series excluded 2005-2008, years which had more restrictive quota, fewer pollock-directed trips, and considered by industry to be unrepresentative of abundance trends. The Framework Model (used here for comparison only), had the same formulation as the Base VPA, but used the full CPUE series for 1982-2008. The adaptive framework, ADAPT (Gavaris1988b), was used to calibrate the sequential population analysis with the CPUE and RV survey age-specific abundance trend results. For this assessment, age 2 was assigned a fixed value based on recent observed recruitment (i.e. geometric mean of past 10 years), and fishing mortality at age 9 for 2007 and 2008 was assumed to be equal to the population number weighted average fishing mortality on ages 7 and 8 .

## Diagnostics

Results for population abundance, F, and biomass are given in tables 11-13, respectively, for the Base VPA, and in tables 14-16 for the Framework VPA. A comparison of VPA model results indicates that age 2 recruitment for the 1999-2003 year classes is higher for the Base VPA compared to the Framework VPA, but lower for the 2004 and 2005 year classes (Fig. 24). Also, age 4+ biomass for the Base model is higher from 2003 on, and shows a steady increase to 2007, declining slightly in 2008. The $20084+$ biomass is estimated at $27,400 \mathrm{t}$ (versus $20,200 \mathrm{t}$
for Framework VPA). Fishing mortality on ages 6-9 is slightly lower in the Base VPA and drops below $\mathrm{F}_{\text {ref }}$ in 2007.

The Base VPA is considered to be a better approach, because it excludes 2005-2008 from the catch rate series, which are not considered to be comparable to other years in the time series. The mean square residuals for the Base model ( $\mathrm{MSR}=0.665163$ ) is slightly higher than the Framework model (MSR = 0.651211), indicating that the fit of the Base model to the survey indices is not quite as good. However, when the entire CPUE series is omitted and only the RV series is used for tuning, the MSR increases to 1.025038. During the 2004 framework assessment, it was concluded that it is useful to have the catch rate series as a tuning index to dampen the year effects apparent in the RV series. This conclusion continues to be valid for the current assessment.

Age-specific residuals for the Base VPA formulation are shown in Fig. 25. The residual pattern for the CPUE series (upper panel) shows a band of positive residuals for ages 4-6 from 1994 to 2004. The model predicts higher abundance than indicated by the CPUE series for ages $3,4,7$, and 8 in 2004. Residuals for the RV series are large and positive for most ages in 2006 (year effect). Large negative residuals occur for ages 7 and 8 in 2008, with the model predicting higher abundance for these age groups than indicated by the survey indices.

The population abundance estimates for the Base VPA show a decreasing trend in relative error in model fit and relative bias for ages 3 through 7, with a slight increase in relative error bias for age 8 (Table 17). However, the relative error for ages 3 (1.765) and 4 (0.830) appears to be quite high and indicates high variability in the estimates of population abundance for these ages. Survey calibration constants (q's) increase with age up to age 7, then decline at age 8. While the age-specific estimates of population numbers and calibration constants are sometimes associated with high variance, they are comparable to those reported in the assessment of this resource in 2006. The CPUE calibration coefficients show high relative error at ages 3 and 4, but these indices are fit to the model using a power function and the coefficients appear to be poorly estimated.

Retrospective analysis for the Base Model VPA indicates a slight tendency to underestimate fishing mortality on ages 6-9, to overestimate $4+$ stock biomass, and to underestimate age 2 recruitment (Fig. 26). Overall, however, there is not a strong retrospective pattern for this model formulation. A comparison of age $3+$ population biomass from the Base VPA and $q$-adjusted age 3-8 total biomass from the RV survey indicates a relatively good fit of the population model to the survey data, despite the several year effects evident in the survey time series (Fig. 27).

## Stock Trends and Current Status

The assessment results were based on the Base age-structured population model for the Western Component that incorporated indices of abundance from both the DFO summer RV survey (1984-2008) and standardized CPUE from the commercial fishery, excluding the most recent 4 years (1982-2004). The model set up for the terminal year involves estimating abundance for ages 3-8, calculating a weighted $F$ for ages 9 and 10 (using the average for ages 7 and 8 ), and assigning a small value for the abundance of ages 11-13.

The 2001 year class was estimated to be slightly lower than indicated during the 2006 assessment ( 12.4 million versus 14.5 million recruits) and was the strongest at age 2 since the 1988 year class (Fig. 28). It is also the third highest in the time series. Initial indications for both the 2002 and 2003 year classes are that they are of average strength at 7.1 and 6.3 million
(geometric mean for time series $=6.7$ million). However, current prospects for the 2004 and 2005 year classes are very poor (1.3 and 1.5 million, respectively).

Estimates of age 4+ (considered spawning stock) biomass declined from about 66,000 t in 1984 to about $7,500 \mathrm{t}$ in 2000. Biomass has been rebuilding since 2000, increasing steadily to about $29,000 \mathrm{t}$ in 2007, and declining to $27,000 \mathrm{t}$ in 2008 (Fig. 28). During the benchmark review, it was concluded that the probability of good recruitment is higher when adult biomass is $>B_{\text {ref }}=30,000 \mathrm{t}$. This conclusion was based on the relationship between age 4+ biomass and age 2 recruits, which, when examined visually, gives an indication that recruitment may be higher when age $4+$ biomass exceeds $30,000 \mathrm{t}$ (Fig. 29). If this is the case, then current levels of age 4+ biomass are below the reference level.

Gains in fishable biomass may be partitioned into those associated with somatic growth of pollock which have previously recruited to the fishery and those associated with new recruitment to the fishery (Rivard 1980). Age 3 was used as a convenient age of first recruitment to the fishery. On average, growth contributes about 70\% of total production, ranging from 60-90\% since 1982 (Fig. 30). Surplus production is defined as the gains in fishable biomass which are in excess of the needs to offset losses from natural mortality. When the fishery yield is less than the surplus production, there is a net increase in the population biomass. Since 1999, there has been a moderate level of production in excess of fishery removals up to 2006. In 2007, surplus production was estimated to be low at $2,770 \mathrm{t}$ compared to $9,074 \mathrm{t}$ in 2006. The yield for age $3+$ increased steadily from 1994 to 2004, but has declined since then, and was estimated at 4,051 t in 2007, a modest increase from 2006.

Fishing mortality rates steadily increased from the early 1980s, to above 1.0 by the early 1990s and remained high until the early 2000s. Subsequent reduced quotas and harvests, as well as increasing population biomass, have contributed to a decline in the fishing mortality rate on ages $6-9$, which has been below the $F_{\text {ref }}$ of 0.2 since 2006 (Fig. 31). The overall prognosis is not quite as optimistic as indicated from the 2006 assessment.

## PROJECTIONS OF CATCH AND POPULATION BIOMASS

Projections were done using the Base VPA results, and a 3-year average (2006-2008) for partial recruitment (except age 4), fishery WAA, and beginning of year WAA. Unlike other 3-year partial recruitment (PR) average values, the 3-year average PR for 2006-2008 increases for all ages, and especially for age 4 (Fig. 32). The latter reflects the low fishery catch at age 4 in 2008. The high PR value for this age group is not considered to be a likely scenario, therefore, age 4 PR was assigned a value of 0.35 for projections and risk analysis. The partial year (2008, Jan.Aug.) was included in all calculations because in previous years, the increment of growth observed in the final trimester was inconsequential. Recruitment was set at 5 million for 2009 and 2010. It was assumed that removals for the remainder of quota year (31 March 2009) would be about $1,400 t$, with removals at $F_{\text {ref }}$ for the next fishing year (2009/2010). The projected age $4+$ population biomass is estimated at $23,400 t$ for 2009 and $24,500 t$ for 2010, but is influenced by assumed recruitment. Age 5+ biomass is expected to decline from 22,200 t in 2009 to 20,300 $t$ on 2010. The projected $2+$ yield in 2009 is estimated at $4,100 \mathrm{t}$ (Table 19); with the 2001 year class at age 8 representing $36 \%$ of the catch biomass.

For the Western Component, the range of harvest strategies in the fishing year that are risk averse ( $25 \%$ risk of exceeding $F_{\text {ref }}$ ) to risk neutral ( $50 \%$ risk of exceeding $F_{\text {ref }}$ ) are about 3,700 t to $4,400 \mathrm{t}$ for age $5+$ (Fig. 33). For the 2009/2010 fishing year, there is a $50 \%$ likelihood that removals of $3,000 \mathrm{t}$ would not allow for any increase in biomass.

Given the high variability in relative error for the current population abundance estimates of ages 3 and 4 (Table 17), and the fact that the abundance of the 2004 and 2005 year classes at age 2 ( 1.3 and 1.5 million, respectively) was estimated to be lower than previously observed for the entire time series (i.e. beyond the range of past model predictions), an alternate base model formulation was examined for projections and risk analyses. For this model, the population abundance at age 2 for 2006-2008 was assigned the lowest observed value of recruitment for the time series ( 3.4 million). Based on this scenario, the range of harvest strategies in the fishing year that are risk averse ( $25 \%$ risk of exceeding $\mathrm{F}_{\text {ref }}$ ) to risk neutral ( $50 \%$ risk of exceeding $F_{\text {reft }}$ ) are about $4,100 t$ to $4,750 t$ for age $5+$ (Fig. 34). For the 2009/2010 fishing year, there is a $50 \%$ likelihood that removals of $4,500 \mathrm{t}$ would not allow for any increase in biomass.

## EASTERN COMPONENT

While most of the fishery now occurs within the Western Component, there remains a need to provide advice on the status of the resource on the Eastern Component, especially in light of the mobile gear test fisheries in 4W in 2007 and 2008. The distribution of catches from the 2007 and 2008 RV surveys is shown in Fig. 17. Several good catches occurred in eastern 4X in 2007 and 2008; these were along the shelf edge ( 4 Xn ), around Emerald and LaHave basins, and along the line separating Eastern and Western components. Two good tows also occurred in 4 V along the edge of the Laurentian Channel in 2007, but there were no good catches in 4 V in 2008.

In 2007, survey biomass in the Eastern Component increased to a level not seen since the early 1990s, and represented $62 \%$ of total biomass (versus $38 \%$ for Western Component) (Fig. 35). Most of this increase is attributed to higher catches from sets in eastern 4 X (i.e. 4 Xmn ), not in 4VW. Biomass declined in the east in 2008, but was still relatively high compared to the past decade. The overall biomass for the $4 \mathrm{VWX}+5$ stock complex has remained relatively high since 2006.

DFO summer survey age-specific indices of abundance for the Eastern Component (strata 440474, 475, 477, and 478; Fig 36) generally indicate a different pattern of year class strength compared to the west (stratas 474, 476, 480-495; Fig. 18). The 2004 year class at age 4 is predominant in 2008, while the 2002 year class at age 5 is strong in 2007 (similar to CAA for 4W; see Fig. 40). Ages 3 and 4 in 2008 and 2007 also appear to be of greater strength compared to the west for these years; however, the strong year effect in 2006, which caused high abundance for all age groups in the west, is not evident in this series. The survey indices also show that there have been relatively few fish older than age 7 since 1997. A comparison of survey weights at age for ages 2, 4, and 6 indicates that pollock from Eastern Component strata generally weigh less for these age groups compared to pollock from Western Component strata (Fig. 37).

Despite minimal landings from the Eastern Component, smoothed estimates of total mortality from the RV survey were high and increasing up to 2005, declined in 2006, then increased again in 2007 (Fig. 38). This recent pattern is likely due to higher abundance in 2007 and lower abundance in 2008. It is difficult to tell from the survey Z if situation in the east is actually improving.

Pollock catch at size and catch at age frequencies from directed fisheries in area 4W during the 1980s and 1990s were examined to see how they compared with the size and age composition from recent (2007/2008) test fisheries in 4W. Length-weight parameters were calculated from
data pooled over the last 10 years from the summer RV survey for stratas 440-473, 475, and 477-478. Pollock were larger in the 1980s compared to 1990s (Fig. 39). Size frequencies from 2007/2008 test fisheries appeared to be similar to both earlier periods, when fisheries took place on the eastern Scotian Shelf. Pollock from the 2008 test fishery were smaller than those landed in 2007 (modal size: 49 versus 55 cm ).

The age composition from the 1980s and 1990s indicates that fish as young as age 3 and 4 represented a considerable percentage of the catch (Fig. 40). During this period, 130 mm diamond mesh cod ends were used for the directed fishery and were capable of retaining small pollock. Noteworthy is that after the mid 1990s, relatively few fish older than age 6 have been captured.

The 2007 test fishery in 4W was represented mainly by fish aged 5 and 6 (2003 and 2002 year classes, respectively), while in 2008, age 4 (2004 year class) comprised much of the catch. A similar age frequency pattern was observed in the RV survey indices for the Eastern Component strata (See Fig. 36).

## ECOSYSTEM IMPACTS

## Bycatch Analyses

The percentage of bycatch kept and bycatch discarded was calculated as a proportion of the total observed catches for 2006-2008 combined ( 3 years since last assessment). For pollockdirected fisheries, the catch composition was examined for observed OTB 1-3 trips in $4 \mathrm{X}, 5 \mathrm{Z}$, and 4W (test fishery), and also for gillnet trips in 4X. For pollock bycatch fisheries, observed trips from the 4 X redfish fishery were examined, since this fishery has landed an average of 475 t of pollock over past 3 years. Other groundfish fisheries (i.e. cod, haddock) also catch pollock, but since the pollock bycatch exceeded that of the directed species, these trips were not examined further.

A proxy for observer coverage for each fishery/gear category was calculated as the observed catch (t)/total landings (t) X 100. Generally, observer coverage has been low for pollock directed and pollock bycatch fisheries; the only exception being the 4 W test fishery with $100 \%$ observer coverage. Over the past 3 years, observer coverage of the directed mobile gear fisheries for pollock in $4 X$ and $5 Z$ has declined to very low levels (i.e. to $1 \%$ by 2008), and only 2 gillnet trips in 4 X were observed over the past 3 years. In the $4 X$ redfish fishery, observer coverage has declined from $5 \%$ in 2006 to only $1 \%$ in 2008, and, as indicated earlier, there is the potential for discarding of small pollock in this fishery.

| Gear Category <br> (species sought) | \% Observer Coverage <br> (observed catch/total landings $\times$ 100) |  |  |
| :--- | :---: | :---: | :---: |
|  |  |  |  |
|  | 2006 | 2007 | 2008 |
| 4X OTB (Pollock) | 2.8 | 2.9 | 1.1 |
| 5Z OTB (Pollock) | 38.7 | 7.9 | 0.6 |
| 4W OTB (Pollock) | - | 100.0 | 100.0 |
| 4X GN (Pollock) | - | - | 1.9 |
| 4X OTB (Redfish) | 4.7 | 3.8 | 1.1 |
|  |  |  |  |

For pollock-directed mobile gear trips in 4X, observed sets occurred in Crowell Basin and the Fundian Channel (Fig. 41). Overall, 96\% of the catch was kept and 4\% was discarded. Pollock represented $92 \%$ of the total catch with very little bycatch, i.e. $2 \%$ haddock, $1 \%$ cod, and $<1 \%$ redfish and white hake, all of which were landed (Fig. 41). Discarded bycatch species included dogfish (2\%), basking shark (2\%), and American lobster (<1\%), plus several other species at very low levels (Table 19).

For pollock-directed mobile gear trips in 5Zc, observed sets occurred along the northeastern edge of Georges Bank (Fig. 42). Overall, 99\% of the catch was kept with 1\% discarded. Pollock represented $91 \%$ of total catch with very little bycatch: $7 \%$ haddock, $1 \%$ cod, and $<1 \%$ redfish, all of which were landed (Fig. 42). Discarded bycatch species included dogfish (1\%), barndoor skate (< 1\%), and American lobster (< 1\%), plus several other species at very low levels (Table 20).

For pollock-directed mobile gear trips in 4W, observed sets occurred in Emerald Basin and along the Shelf slope (Fig. 43). Overall, $99 \%$ of the catch was kept and $1 \%$ was discarded. Pollock represented $98 \%$ of total catch, redfish $1 \%$, haddock and cod < 1\%; all were landed (Fig. 43). The discarded bycatch species was mainly "Russian hat" sponges (1\%), plus several other species at very low levels. Generally there was very little bycatch in this fishery (Table 21).

For pollock-directed gillnet trips in 2008, observed sets occurred mainly in 4 Xq around Jordan Basin (Fig. 44). Overall, $82 \%$ of the catch was kept, with $18 \%$ discarded. Pollock represented $61 \%$ of total kept catch with a bycatch of $15 \%$ white hake, $4 \%$ cod, $2 \%$ shortfin mako, and $<1 \%$ thresher shark, all of which were landed (Fig. 44). Discarded bycatch species included basking shark (14\%), spiny dogfish (1\%), white hake (1\%), pollock (1\%), plus several other species at low levels (i.e. cod, American shad, blue shark; Table 22).

For redfish-directed mobile gear trips in 4 X , observed sets occurred in Crowell, Jordan, and LaHave basins (Fig. 45). Overall, $87 \%$ of the catch was kept, with $13 \%$ discarded. Redfish represented $58 \%$ of total catch, pollock $22 \%$, haddock $3 \%$, cod and white hake approximately 1\%; all were landed (Fig. 45). Discarded bycatch species was mainly dogfish (12\%), with some lobster ( $0.5 \%$ ), plus several other species at very low levels (Table 23).

## Habitat Impacts

Offshore pollock aggregations are associated with hard bottom topographic features, such as rises, ridges, or mounts, and the location of mobile and fixed gear fisheries are often in close proximity to these features. Some of these are areas of high complexity and high energy (currents generated by tides, wind, and storms). The physical effects on the bottom from pollock fisheries using mobile and fixed gear, and subsequent effects on benthic communities are unknown. While some information exists on the effects of bottom trawl fisheries (DFO 2006), very specific studies would be required to assess the impact of pollock fisheries on benthic communities.

## Predator/Prey Interactions

## Food Habits

The food habits of pollock were previously described by Carruthers et al. (2005) using data obtained from research surveys on Scotian Shelf during the 1950s and 1960s, and from 1996 to 2002. This work had 3 main findings; first, the increased consumption of fish prey by larger pollock was both temporally and spatially stable. Second, the condition factor of pollock was
decreasing during current time periods. The third, and perhaps the more significant finding, was the temporal change in pollock's primary prey item from krill in the 1950s and 1960s to fish through the 1990s and early 2000s. The decreased abundance of krill as prey coincided with decreases in this prey item across the Shelf as revealed through Continuous Plankton Recorder data (Carruthers et al. 2005).

The diet analysis of Caruthers et al. (2005) was updated using pollock stomach content data that was not previously available from a series of non-standard surveys, as well as new diet information collected from DFO RV surveys conducted from 2003-2008.

Results from the updated analysis confirmed that krill was one of the most important prey items by weight for all size classes of pollock during the pre 1970s, particularly in 4X (Fig. 46). Analysis of stomach content data from the 1996 RV survey showed that krill was replaced by shrimp, amphipods, and fish, as the largest contributors to the diet (Fig. 46). Stomach content data from the 2003 RV survey showed that krill is once again a large component of the diet in 4X (Fig. 46). Similar to the previous work, pollock showed an increase in piscivory with increasing body size across all data sources (Fig. 46). Concurrent with the increases in fish as prey, krill, amphipods, and shrimp showed a decrease in the diet of large pollock.

Seasonal changes in diet were examined for data collected during the pre 1970s as this dataset had the best spatial coverage of the Scotian Shelf/Bay of Fundy. In 4X, diet was stable over the year with krill being a consistently key component of the diet (Fig. 47). In contrast, 4VW shows seasonal changes with krill being important in spring, but during autumn and winter fish are a more important prey item (Fig. 48).

Prey fish of pollock appear to be relatively consistent with silver hake, herring, and sand lance being the largest contributors (Fig. 49). However, regional and season comparisons also show that haddock, lanternfish, and redfish are important components of the diet.

## Feeding Behaviour and Condition

Pollock show diel feeding patterns with the highest fullness indices during the early evening ( $4-8 \mathrm{pm}$ ) over summer, autumn, and winter in both the pre 1970s and 1995-2008 RV data (Fig. 50). Spring, however, shows a different pattern of fullness with a peak during the morning hours of $10 \mathrm{am}-12 \mathrm{pm}$. Spring is also the season with the highest proportion of empty stomachs, which may be due to a post spawning recovery period.

The condition of pollock (as calculated from area specific survey length weight relationships) declined through to the late 1990s in both 4X and 4VW (Fig. 51). However, since then, it has been variable but stable. The main decline occurred during the 1980s. This does not correspond to any observed changes in diet, which occurred later in the 1990s. However, it does correspond to the period when krill were thought to decline (Carruthers et al. 2005).

## Predation

Pollock are prey to several species, including cod, white hake, silver hake, and sea raven, and are consumed across their area of distribution (Table 24). None of the predators appear to strongly prefer pollock as prey, as they are never found in more than $0.4 \%$ of stomachs examined. Pollock at approximately 15 cm are most commonly observed as prey. It is interesting to note that pollock predation was much higher in 1999 than other sampled years.

## SOURCES OF UNCERTAINTY

- Trends in mobile gear catch rates for 2005-2008 appear to be confounded by changes in the fishery and management practices not associated with trends in abundance. Including the CPUE time series as a tuning index improved the model fit, but catch rates since 2004 are not included because they may no longer reflect abundance.
- Pollock, being a semi-pelagic, schooling species, are less well sampled by the summer RV survey than other gadoids. This creates high variability in the RV abundance index from year to year, especially for age 3.
- The VPA results showed high relative error for the current population abundance estimates of ages 3 and 4, and generated low estimates for population abundance at age 2 (recruitment) for 2004 and 2005, which were beyond the range of past model predictions. If the lowest observed level of predicted recruitment for the VPA time series ( 3.4 million recruits) is used for projections and risk analyses, harvest strategies are more optimistic.
- There is a concern over the lack of summer survey coverage on the Canadian portion of Georges Bank, which is part of the Western Stock Component. Excluding this area from the survey indices could make a difference to the assessment results, if the pollock biomass on Georges Bank was increasing or decreasing more than the biomass in 4X.
- There is uncertainty as to whether the pollock observed in 4 Xmn during the summer survey are the same fish captured in the 4W fall test fisheries (although the size and age composition appears to be similar).
- There is a lack of fishery size/age composition data for fixed gear fisheries in the Eastern Component.
- Discarding of small pollock from the 4Xpq redfish fishery may compromise catch at age calculations.
- The level of observer coverage in 4 X is far too low to provide meaningful bycatch estimates.


## CONCLUSIONS AND ADVICE

## Western Component

Using the Base Model formulation, age 4+ population biomass for the Western Component in 2008 is about $27,000 \mathrm{t}$. The probability of good recruitment is higher when adult biomass is $>\mathrm{B}_{\text {ref }}=30,000 \mathrm{t}$. Fishing mortality on fully recruited ages 6-9 showed a further decline from 2006 and has been below $\mathrm{F}_{\text {ref }}=0.2$ for the past 2 years. Population age structure appears to be improving at the current level of $F$ (i.e. more older fish are present), but early signs for recruitment of the 2004 and 2005 year classes suggest they may be very weak. The 2002 and 2003 year classes are currently estimated to be about average.

The range of harvest strategies in the 2009/2010 fishing year that are risk averse ( $25 \%$ risk of exceeding $F_{\text {ref }}$ ) to risk neutral ( $50 \%$ risk of exceeding $F_{\text {ref }}$ ) are about 3,700 to 4,400 $t$. If fished at $F_{\text {ref, }}$, the projected 2009/2010 2+ catch biomass is $4,100 \mathrm{t}, 83 \%$ of which will be represented by ages 6-8. At this level of harvest, age $5+$ population biomass will continue to decrease from 2009 to 2010.

Alternatively, if recruitment at age 2 for the 2004 and 2005 year classes is not as low as the model estimate and is set to the lowest observed level in the time series ( 3.4 million), then the range of harvest strategies (risk averse to risk neutral) is about 4,100 to $4,750 \mathrm{t}$. If fished at $F_{\text {ref }}$,
the projected 2009/2010, age $2+$ catch biomass is $4,500 \mathrm{t}$, and at this harvest level, population biomass is expected to stay the same from 2009 to 2010.

These harvest strategies are for 4 Xopqrs +5 and would be conservative if applied to all of 4X, since an additional 300-400 t of removals have occurred from $4 \times \mathrm{mn}$ over the past 2 years. This risk analyses does not incorporate the uncertainties as noted above and overstates the precision of the estimates of $F_{\text {ref }}$ yield outcomes.

## Eastern Component

The summer survey biomass index for the Eastern Component has increased since 2006; most of this increase is due to good catches in 4 Xmn , but not in 4 VW . Pollock from the Eastern Component are smaller in size at age than those from the Western Component, and are represented by proportionally more younger aged fish. Estimates of total mortality from the RV survey indicate a decrease in Z for 2006 and 2007 due to higher abundance in the 2007/2008 surveys; however, it is too early to tell if the situation is actually improving.

The 4W test fishery size composition is similar to what has been observed in past decades, but pollock captured in 2008 were smaller than 2007. These fish were mainly ages 5 and 6 in 2007 and age 4 in 2008. A similar age frequency suggests continuity between 4 Xmn and 4 W .

Total removals from 4W by all gear sectors was 715 t in 2007 and 514 t in 2008. While the current level of removals has allowed for some rebuilding of the Eastern Component (i.e. in 4 Xmn ), it is not rebuilt yet (i.e. 4 V ). Relative F for all Eastern Component fisheries landings/survey biomass) is low at $2.55 \%$ and $1.85 \%$ for 2007 and 2008, respectively. Therefore, directed pollock fisheries for the east should proceed with caution.

There is a requirement for better sampling of fixed gear and mobile gear catches in 4 Xmn and 4 W . DFO port sampling for these trips is only available if vessels land west of Shelburne.

## Bycatch

With the exception of the 2007/2008 4W test fisheries and, to a lesser extent, 5Z, observer coverage of pollock directed fisheries is very low, and has been implemented largely to address management issues. Notwithstanding these limitations, most of the total catch (82-99\%) is landed and counted against respective quotas for these species. Dogfish appears to be the most commonly discarded bycatch species, with other species occurring at low levels.

Pollock are also caught in the small mesh redfish fishery, particularly in Crowell, Jordan, and LaHave basins, and represent $22 \%$ of the observed total catch weight for 2006-2008. Based on comparisons of port (dockside) and observer (at-sea) size compositions, pollock < 40 cm may be discarded at-sea.

Bycatch discards may also occur in the 4X pollock gillnet fishery, but observer coverage is far too low (i.e. 2 trips for 2006-2008) to make any conclusions.

## Habitat

The habitat over which the directed pollock fishery takes place is highly energetic and of high complexity. The impact of the pollock fishery on the sea floor is currently unknown.

## Food and Feeding Habits

The diet of pollock from the Scotian Shelf and Bay of Fundy has shown decadal changes, with euphausiids (krill) being predominant in the diet in the1960s, less so in the 1990s, and once again since 2003.

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Table 1. Landings of pollock by country in 4VWX5. The landings for 2008 represent a partial year (Jan. 1 to Aug. 31).

|  | Canada | Japan | France | Fed. Rep. Germany | German Dem. Rep. | Cuba | USSR (Russia) | USA | Spain | Other | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1974 | 24975 | 40 |  | 149 |  |  | 2301 | 435 | 1500 | 61 | 29461 |
| 1975 | 26548 |  |  | 236 | 95 |  | 2004 | 403 | 708 | 124 | 30118 |
| 1976 | 23565 |  |  | 994 | 24 |  | 1466 | 443 | 303 | 385 | 27180 |
| 1977 | 24653 | 1 |  | 368 |  |  | 182 | 325 |  | 53 | 25582 |
| 1978 | 26801 | 110 | 33 |  |  | 141 | 502 | 451 |  |  | 28038 |
| 1979 | 29967 | 19 | 23 |  |  | 50 | 1025 | 391 |  | 7 | 31482 |
| 1980 | 35986 | 81 | 99 |  |  | 32 | 950 | 443 |  |  | 37591 |
| 1981 | 40270 | 15 | 90 |  |  |  | 358 | 918 |  |  | 41651 |
| 1982 | 38029 | 3 | 44 |  |  | 84 | 297 | 1107 |  |  | 39564 |
| 1983 | 32749 | 6 | 22 |  |  | 261 | 226 | 1854 |  |  | 35118 |
| 1984 | 33465 | 1 | 46 |  |  | 123 | 97 | 2272 |  | 1 | 36005 |
| 1985 | 43300 | 17 | 77 |  |  | 66 | 336 | 152 |  |  | 43948 |
| 1986 | 43249 | 51 | 77 |  |  | 387 | 564 | 234 |  | 4 | 44566 |
| 1987 | 45330 | 82 | 28 |  |  | 343 | 314 | 102 |  |  | 46199 |
| 1988 | 41831 | 1 |  |  |  | 225 | 1054 | 60 |  |  | 43171 |
| 1989 | 41112 | 1 |  |  |  | 99 | 1782 | 35 |  |  | 43029 |
| 1990 | 36178 |  |  |  |  | 261 | 1040 | 213 |  |  | 37692 |
| 1991 | 37931 | 38 |  |  |  | 459 | 1177 | 68 |  |  | 39673 |
| 1992 | 32002 | 72 | 9 |  |  | 1015 | 1006 | 57 |  |  | 34161 |
| 1993 | 20253 |  |  |  |  | 644 | 176 |  |  |  | 21073 |
| 1994 | 15240 |  |  |  |  | 10 |  |  |  |  | 15250 |
| 1995 | 9781 |  |  |  |  | 58 |  |  |  |  | 9839 |
| 1996 | 9145 |  |  |  |  | 129 | 6 |  |  |  | 9280 |
| 1997 | 11927 |  |  |  |  | 64 |  |  |  |  | 11991 |
| 1998 | 14371 |  |  |  |  | 9 | 1 |  |  |  | 14381 |
| 1999 | 7738 |  |  |  |  | 6 |  |  |  |  | 7744 |
| 2000 | 5672 |  |  |  |  |  |  |  |  |  | 5672 |
| 2001 | 6318 |  |  |  |  |  |  |  |  |  | 6318 |
| 2002 | 7090 |  |  |  |  |  |  |  |  |  | 7090 |
| 2003 | 8090 |  |  |  |  |  |  |  |  |  | 8090 |
| 2004 | 8353 |  |  |  |  |  |  |  |  |  | 8353 |
| 2005 | 7528 |  |  |  |  |  |  |  |  |  | 7528 |
| 2006 | 3965 |  |  |  |  |  |  |  |  |  | 3965 |
| 2007 | 5799 |  |  |  |  |  |  |  |  |  | 5799 |
| 2008 | 4096 |  |  |  |  |  |  |  |  |  | 4096 |

Table 2. Pollock landings ( t ) by area in the Western Component, (4Xopqrs, 5 Yb in Canadian waters, and $5 Z \mathrm{c}$ ). The landings for 2008 represent a partial year (Jan. 1 to Aug. 31).

|  | 4Xo | 4Xp | 4Xq | 4Xr | 4Xs | 4Xu | 5Yb | 5Zc | Total |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 1982 | 4781 | 1499 | 2675 | 2508 | 1345 | 183 | 925 | 4430 | 18347 |
| 1983 | 4337 | 1146 | 3635 | 1170 | 461 | 1319 | 1079 | 3301 | 16448 |
| 1984 | 3536 | 1189 | 4541 | 716 | 163 | 1933 | 2015 | 1199 | 15291 |
| 1985 | 6179 | 595 | 5718 | 1284 | 696 | 3275 | 853 | 911 | 19511 |
| 1986 | 7326 | 1073 | 2531 | 1046 | 1287 | 2066 | 654 | 1538 | 17520 |
| 1987 | 4734 | 2329 | 1893 | 508 | 1209 | 2571 | 1120 | 2096 | 16460 |
| 1988 | 3194 | 3417 | 3333 | 307 | 790 | 4110 | 345 | 2403 | 17899 |
| 1989 | 3619 | 3373 | 2334 | 332 | 374 | 1777 | 531 | 1385 | 13724 |
| 1990 | 3668 | 2523 | 2953 | 1042 | 693 | 2629 | 346 | 1740 | 15595 |
| 1991 | 4621 | 3745 | 2665 | 2465 | 2105 | 831 | 456 | 1715 | 18602 |
| 1992 | 4174 | 1528 | 2626 | 2175 | 1793 | 865 | 443 | 3036 | 16639 |
| 1993 | 2754 | 1985 | 2226 | 1605 | 941 | 337 | 368 | 4193 | 14410 |
| 1994 | 1860 | 1097 | 1213 | 1453 | 866 | 784 | 236 | 3327 | 10836 |
| 1995 | 429 | 1158 | 2552 | 676 | 393 | 683 | 250 | 1004 | 7144 |
| 1996 | 419 | 1478 | 1811 | 686 | 412 | 179 | 256 | 1200 | 6441 |
| 1997 | 446 | 1574 | 4030 | 1112 | 607 | 447 | 311 | 1231 | 9759 |
| 1998 | 437 | 3495 | 3134 | 564 | 469 | 153 | 425 | 1857 | 10534 |
| 1999 | 313 | 879 | 1372 | 648 | 380 | 37 | 135 | 996 | 4760 |
| 2000 | 257 | 1086 | 1531 | 264 | 249 | 47 | 136 | 1197 | 4768 |
| 2001 | 207 | 1191 | 1774 | 301 | 186 | 68 | 104 | 1569 | 5400 |
| 2002 | 201 | 1482 | 2628 | 189 | 159 | 52 | 157 | 1616 | 6485 |
| 2003 | 114 | 1823 | 2578 | 403 | 665 | 316 | 594 | 1347 | 7839 |
| 2004 | 58 | 2404 | 2342 | 321 | 557 | 147 | 137 | 2047 | 8012 |
| 2005 | 126 | 3397 | 970 | 221 | 324 | 43 | 108 | 1740 | 6928 |
| 2006 | 99 | 1187 | 781 | 95 | 290 | 42 | 128 | 848 | 3469 |
| 2007 | 109 | 2004 | 1562 | 168 | 133 | 56 | 95 | 552 | 4679 |
| 2008 | 76 | 1552 | 1501 | 20 | 18 | 39 | 87 | 330 | 3623 |

Table 3. Pollock landings ( t ) by area in the Eastern Component ( $4 \mathrm{VW}+4 \mathrm{Xmn}$ ). The landings for 2008 represent a partial year (Jan. 1 to Aug. 31).

|  | 4Vn | 4Vs | 4 Vu | 4Wd | 4We | 4Wf | 4Wg | 4Wh | 4Wj | 4Wk | 4WI | 4Wm | 4Wu | 4Xm | 4Xn | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1982 | 149 | 2216 | 162 | 4 | 89 | 8 | 230 | 904 | 3181 | 1987 | 2469 | 25 | 69 | 4341 | 3154 | 18987 |
| 1983 | 104 | 5214 | 13 | 7 | 189 | 24 | 621 | 1577 | 235 | 1725 | 702 | 7 | 191 | 2713 | 2532 | 15855 |
| 1984 | 351 | 4598 | 101 | 5 | 60 | 9 | 207 | 1699 | 252 | 2061 | 1406 |  | 106 | 2251 | 3805 | 16912 |
| 1985 | 839 | 9375 | 7 | 79 | 80 | 6 | 1002 | 198 | 32 | 1156 | 247 |  | 43 | 4803 | 3014 | 20882 |
| 1986 | 1379 | 11639 | 138 | 202 | 30 | 2 | 658 | 289 | 454 | 986 | 239 |  | 220 | 4124 | 2448 | 22808 |
| 1987 | 915 | 9680 | 303 | 70 | 26 | 0 | 416 | 92 | 659 | 2302 | 29 |  | 154 | 4947 | 5987 | 25583 |
| 1988 | 1448 | 9307 | 224 | 128 | 85 | 10 | 746 | 124 | 44 | 934 | 841 |  | 165 | 5020 | 2599 | 21674 |
| 1989 | 4465 | 7542 |  | 253 | 79 | 30 | 313 | 253 | 272 | 1394 | 931 | 6 | 309 | 4239 | 5689 | 25774 |
| 1990 | 2124 | 6065 |  | 90 | 20 | 80 | 769 | 160 | 300 | 1172 | 1093 | 46 | 350 | 3078 | 3886 | 19233 |
| 1991 | 1043 | 3009 |  | 193 | 42 | 7 | 2146 | 132 | 477 | 1329 | 2229 | 106 | 72 | 2824 | 5172 | 18779 |
| 1992 | 284 | 2129 |  | 149 | 98 | 13 | 990 | 101 | 162 | 1064 | 2695 | 44 | 387 | 1594 | 5357 | 15066 |
| 1993 | 86 | 743 |  | 81 | 470 | 1 | 114 | 6 | 5 | 588 | 272 | 1 | 63 | 739 | 2563 | 5731 |
| 1994 | 437 | 329 |  | 19 | 434 | 0 | 69 | 11 | 4 | 787 | 60 |  | 6 | 878 | 1128 | 4161 |
| 1995 | 397 | 665 |  | 36 | 3 | 0 | 108 | 31 | 1 | 130 | 188 | 6 | 135 | 220 | 592 | 2513 |
| 1996 | 30 | 432 |  | 35 | 0 | 0 | 19 | 44 | 0 | 747 | 67 | 1 | 81 | 305 | 898 | 2660 |
| 1997 | 10 | 135 |  | 7 | 1 | 0 | 1 | 94 | 0 | 606 | 66 | 1 | 73 | 305 | 770 | 2071 |
| 1998 | 155 | 171 |  | 11 | 16 | 0 | 36 | 63 | 2 | 149 | 1160 | 1 | 20 | 257 | 1767 | 3806 |
| 1999 | 29 | 422 |  | 0 | 0 |  | 80 | 61 | 1 | 1067 | 248 | 0 | 3 | 247 | 803 | 2963 |
| 2000 | 6 | 234 |  | 0 | 0 |  | 20 | 2 | 0 | 145 | 85 | 0 | 7 | 153 | 239 | 891 |
| 2001 | 0 | 94 |  | 0 | 0 |  | 7 | 2 | 0 | 128 | 151 | 2 | 15 | 146 | 336 | 882 |
| 2002 | 0 | 39 |  |  | 0 |  | 0 | 2 | 0 | 37 | 39 | 0 | 1 | 77 | 317 | 513 |
| 2003 | 0 | 4 |  | 0 | 0 |  | 1 | 5 | 0 | 15 | 37 | 0 | 4 | 24 | 152 | 243 |
| 2004 | 0 | 9 |  |  |  |  |  | 2 | 0 | 25 | 135 |  | 1 | 25 | 144 | 340 |
| 2005 | 8 | 4 |  |  | 0 |  | 0 | 1 | 0 | 81 | 75 |  | 7 | 44 | 379 | 599 |
| 2006 | 0 | 15 | 0 | 0 |  |  | 0 | 5 | 0 | 67 | 98 |  | 0 | 42 | 269 | 496 |
| 2007 | 0 | 3 | 1 |  |  | 10 | 0 | 0 | 1 | 462 | 234 |  | 8 | 67 | 333 | 1120 |
| 2008 | 0 | 0 |  |  |  |  | 0 | 1 |  | 40 | 18 |  | 1 | 46 | 366 | 473 |

Table 4. Pollock landings (t) by month in the Western Component, (4Xopqrs, 5 Yb in Canadian waters, and $5 Z \mathrm{C}$ ). The landings for 2008 represent a partial year (Jan. 1 to Aug. 31).

|  | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 1982 | 766 | 667 | 258 | 196 | 1555 | 2789 | 3413 | 2510 | 2317 | 2085 | 1140 | 620 | 18317 |
| 1983 | 1147 | 805 | 477 | 495 | 1814 | 4650 | 3272 | 1659 | 1207 | 568 | 172 | 77 | 16344 |
| 1984 | 167 | 170 | 362 | 753 | 1413 | 3922 | 3818 | 1619 | 1325 | 1090 | 346 | 91 | 15076 |
| 1985 | 114 | 681 | 841 | 1892 | 981 | 4503 | 5243 | 1885 | 1556 | 1048 | 357 | 222 | 19323 |
| 1986 | 1023 | 682 | 758 | 452 | 2221 | 3015 | 3678 | 2649 | 2069 | 664 | 169 | 23 | 17404 |
| 1987 | 1428 | 648 | 643 | 34 | 2212 | 3686 | 2797 | 1905 | 1431 | 490 | 114 | 836 | 16224 |
| 1988 | 1043 | 563 | 140 | 375 | 912 | 4213 | 4534 | 1241 | 1159 | 409 | 151 | 2561 | 17301 |
| 1989 | 645 | 1473 | 329 | 459 | 712 | 3740 | 1682 | 1230 | 1140 | 561 | 1317 | 320 | 13607 |
| 1990 | 244 | 233 | 44 | 132 | 1039 | 3199 | 3465 | 2944 | 2002 | 1182 | 465 | 923 | 15874 |
| 1991 | 1091 | 884 | 433 | 1235 | 1884 | 3435 | 3189 | 2136 | 1750 | 1335 | 729 | 681 | 18783 |
| 1992 | 432 | 625 | 222 | 783 | 1744 | 2916 | 3073 | 2414 | 1813 | 1572 | 817 | 232 | 16644 |
| 1993 | 1089 | 654 | 633 | 385 | 1202 | 2725 | 2741 | 1684 | 1172 | 550 | 900 | 629 | 14363 |
| 1994 | 36 | 244 | 228 | 517 | 801 | 1931 | 2950 | 1350 | 1061 | 903 | 473 | 489 | 10981 |
| 1995 | 106 | 217 | 206 | 472 | 319 | 2013 | 1406 | 255 | 1472 | 255 | 300 | 180 | 7200 |
| 1996 | 277 | 199 | 222 | 223 | 470 | 786 | 1226 | 914 | 544 | 606 | 387 | 604 | 6457 |
| 1997 | 56 | 458 | 508 | 681 | 597 | 1482 | 1917 | 1392 | 1209 | 661 | 560 | 282 | 9802 |
| 1998 | 285 | 624 | 807 | 711 | 953 | 1872 | 2193 | 1109 | 986 | 789 | 165 | 51 | 10544 |
| 1999 | 64 | 59 | 174 | 236 | 348 | 781 | 1112 | 825 | 666 | 215 | 180 | 111 | 4771 |
| 2000 | 135 | 272 | 301 | 98 | 318 | 738 | 850 | 684 | 553 | 506 | 184 | 140 | 4778 |
| 2001 | 231 | 46 | 417 | 224 | 418 | 775 | 1180 | 566 | 610 | 534 | 261 | 146 | 5410 |
| 2002 | 139 | 268 | 328 | 415 | 947 | 1346 | 1266 | 599 | 505 | 345 | 221 | 121 | 6501 |
| 2003 | 39 | 235 | 941 | 643 | 893 | 1171 | 1205 | 901 | 877 | 450 | 374 | 116 | 7845 |
| 2004 | 48 | 514 | 871 | 527 | 676 | 1806 | 1547 | 764 | 560 | 367 | 245 | 85 | 8012 |
| 2005 | 398 | 1065 | 547 | 448 | 536 | 1460 | 835 | 543 | 371 | 302 | 404 | 19 | 6928 |
| 2006 | 220 | 143 | 344 | 161 | 251 | 533 | 426 | 440 | 283 | 301 | 310 | 57 | 3469 |
| 2007 | 61 | 289 | 654 | 472 | 876 | 502 | 643 | 581 | 367 | 152 | 58 | 19 | 4675 |
| 2008 | 98 | 251 | 388 | 455 | 709 | 577 | 622 | 521 |  |  |  |  | 3620 |

Table 5. Pollock landings (t) by gear in the Western Component, (4Xopqrs, 5 Yb in Canadian waters, and 5Zc). The landings for 2008 represent a partial year (Jan. 1 to Aug. 31).

|  | Gillnet | OTB 4+ | Longline | Misc | OTB 1-3 | Total |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: |
|  |  |  |  |  |  |  |
| 1982 | 2574 | 6782 | 2315 | 241 | 6435 | 18347 |
| 1983 | 2416 | 4307 | 1618 | 25 | 8081 | 16448 |
| 1984 | 1809 | 1623 | 1615 | 39 | 10204 | 15291 |
| 1985 | 3045 | 1246 | 2443 | 52 | 12725 | 19511 |
| 1986 | 4378 | 1928 | 4447 | 55 | 6712 | 17519 |
| 1987 | 4003 | 3465 | 2934 | 26 | 6032 | 16460 |
| 1988 | 3021 | 5904 | 1704 | 93 | 7177 | 17899 |
| 1989 | 4217 | 3558 | 1391 | 78 | 4480 | 13724 |
| 1990 | 4810 | 3027 | 2252 | 95 | 5411 | 15595 |
| 1991 | 3572 | 3884 | 2387 | 132 | 8627 | 18602 |
| 1992 | 3784 | 3135 | 2789 | 3 | 6928 | 16639 |
| 1993 | 3159 | 3983 | 2199 | 1 | 5067 | 14410 |
| 1994 | 2760 | 1703 | 2019 | 44 | 4310 | 10836 |
| 1995 | 2620 | 951 | 506 | 4 | 3062 | 7144 |
| 1996 | 1301 | 1733 | 605 | 3 | 2799 | 6441 |
| 1997 | 2312 | 1648 | 978 | 1 | 4820 | 9759 |
| 1998 | 3076 | 1323 | 621 | 21 | 5492 | 10534 |
| 1999 | 1431 | 546 | 494 | 5 | 2286 | 4761 |
| 2000 | 1796 | 516 | 278 | 5 | 2172 | 4768 |
| 2001 | 1776 | 564 | 291 | 1 | 2765 | 5398 |
| 2002 | 1621 | 559 | 229 | 1 | 4074 | 6484 |
| 2003 | 1902 | 11 | 217 | 9 | 5699 | 7839 |
| 2004 | 2017 | 90 | 121 | 1 | 5782 | 8012 |
| 2005 | 1356 | 80 | 125 | 0 | 5365 | 6926 |
| 2006 | 929 | 354 | 87 | 0 | 2095 | 3465 |
| 2007 | 1027 | 149 | 180 | 0 | 3313 | 4668 |
| 2008 | 796 |  | 92 | 0 | 2725 | 3613 |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table 6. Summary of pollock sampling in 2006, 2007, and 2008 (Trimesters 1 and 2) from port (dockside) and observer (at-sea) collections. "Ages" refers to the number of ages used in catch at age calculations.

| Year | Number measured/aged |  |  | Landings (t) |  |
| :--- | ---: | ---: | ---: | ---: | ---: |
|  | Port Samples | Observer <br> Samples |  |  |  |
| 2006 (West) | $9,557(42)$ | $17,416(487)$ | 1111 | 3,465 |  |
| 2007 (West) | $14,249(66)$ | $5,094(127)$ | 1649 | 4,679 |  |
| 2007 (East) | $2,008(8)$ | $8,902(73)$ | 293 | 1,120 |  |
| 2008 (WestT1\&2) | $9,818(48)$ | 3,540 | $(82)$ | 1194 | 3,613 |
| 2008 (EastT1\&T2) | 1,857 | $(6)$ | 7,740 | $(8)$ | 264 |

Table 7. Total catch at age (000s) for pollock in the Western Component (4Xopqrs 5Yb in Canadian waters and 5 Zc ). The catch at age for 2008 includes Jan. 1 to Aug. 31.

|  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1982 | 95 | 1618 | 1352 | 371 | 1031 | 838 | 425 | 145 | 45 | 33 | 13 | 0 |
| 1983 | 45 | 1283 | 3966 | 854 | 179 | 314 | 291 | 138 | 59 | 17 | 19 | 0 |
| 1984 | 4 | 370 | 1832 | 2751 | 465 | 85 | 148 | 114 | 41 | 19 | 2 | 0 |
| 1985 | 5 | 195 | 621 | 1806 | 2142 | 328 | 38 | 100 | 99 | 62 | 30 | 0 |
| 1986 | 1 | 162 | 1410 | 1136 | 1329 | 876 | 88 | 37 | 37 | 41 | 15 | 0 |
| 1987 | 5 | 104 | 628 | 1622 | 883 | 786 | 490 | 68 | 17 | 15 | 28 | 0 |
| 1988 | 19 | 425 | 990 | 1126 | 1281 | 519 | 424 | 242 | 22 | 14 | 20 | 0 |
| 1989 | 93 | 386 | 1533 | 1129 | 576 | 463 | 147 | 129 | 65 | 6 | 7 | 0 |
| 1990 | 47 | 776 | 1102 | 1621 | 873 | 429 | 174 | 138 | 49 | 23 | 10 | 0 |
| 1991 | 58 | 1013 | 1900 | 1506 | 1395 | 347 | 157 | 56 | 49 | 25 | 10 | 0 |
| 1992 | 46 | 1250 | 2678 | 1651 | 675 | 314 | 124 | 96 | 61 | 14 | 12 | 0 |
| 1993 | 4 | 551 | 1989 | 2125 | 1143 | 318 | 92 | 27 | 10 | 7 | 6 | 0 |
| 1994 | 51 | 259 | 675 | 1327 | 1151 | 494 | 166 | 59 | 14 | 8 | 2 | 0 |
| 1995 | 24 | 263 | 537 | 949 | 676 | 294 | 63 | 17 | 4 | 1 | 1 | 0 |
| 1996 | 14 | 202 | 949 | 710 | 473 | 256 | 55 | 15 | 0 | 0 | 1 | 0 |
| 1997 | 6 | 151 | 900 | 1654 | 780 | 217 | 54 | 4 | 0 | 1 | 0 | 0 |
| 1998 | 7 | 228 | 829 | 1368 | 1262 | 307 | 47 | 16 | 2 | 1 | 0 | 0 |
| 1999 | 13 | 89 | 496 | 621 | 426 | 173 | 22 | 4 | 1 | 2 | 0 | 0 |
| 2000 | 86 | 581 | 404 | 592 | 319 | 139 | 27 | 6 | 1 | 0 | 0 | 0 |
| 2001 | 15 | 335 | 814 | 571 | 314 | 91 | 14 | 5 | 2 | 1 | 1 | 0 |
| 2002 | 7 | 191 | 787 | 1073 | 416 | 127 | 20 | 6 | 1 | 0 | 0 | 0 |
| 2003 | 2 | 111 | 1302 | 1331 | 513 | 120 | 18 | 5 | 1 | 1 | 0 | 0 |
| 2004 | 2 | 173 | 542 | 1876 | 696 | 118 | 13 | 4 | 2 | 1 | 0 | 0 |
| 2005 | 0 | 37 | 842 | 759 | 1160 | 170 | 13 | 5 | 1 | 0 | 0 | 0 |
| 2006 | 1 | 30 | 154 | 534 | 353 | 218 | 18 | 3 | 0 | 0 | 0 | 0 |
| 2007 | 5 | 68 | 366 | 447 | 622 | 230 | 27 | 3 | 1 | 0 | 0 | 0 |
| 2008 | 19 | 86 | 157 | 356 | 388 | 231 | 39 | 8 | 1 | 0 | 0 | 0 |

Table 8. Mean weights at age (kg) for pollock from the commercial landings in the Western Component (4Xopqrs +5 ), 1982-2008. Weights at age for 2008 represent a partial year (Jan. 1 to Aug. 31).

|  | Age1 | Age2 | Age3 | Age4 | Age5 | Age6 | Age7 | Age8 | Age9 | Age10 | Age11 | Age12 |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1982 | 0.000 | 0.943 | 1.427 | 2.529 | 3.462 | 4.211 | 4.772 | 5.681 | 6.239 | 7.687 | 8.622 | 10.621 |
| 1983 | 0.000 | 0.881 | 1.349 | 1.983 | 3.373 | 4.367 | 5.105 | 5.651 | 6.624 | 7.220 | 8.381 | 8.886 |
| 1984 | 0.000 | 0.914 | 1.635 | 2.331 | 3.005 | 4.078 | 5.401 | 6.062 | 6.208 | 6.661 | 7.230 | 9.725 |
| 1985 | 0.000 | 0.974 | 1.615 | 2.462 | 3.169 | 3.695 | 4.296 | 6.022 | 7.315 | 7.185 | 7.968 | 9.343 |
| 1986 | 0.000 | 0.738 | 1.554 | 2.306 | 3.095 | 3.929 | 4.530 | 5.791 | 6.651 | 7.161 | 7.322 | 8.698 |
| 1987 | 0.000 | 0.943 | 1.475 | 2.266 | 3.046 | 3.564 | 4.315 | 4.907 | 5.300 | 6.794 | 7.482 | 7.909 |
| 1988 | 0.000 | 1.195 | 1.549 | 2.240 | 3.096 | 3.807 | 4.191 | 4.979 | 5.886 | 7.073 | 8.169 | 8.454 |
| 1989 | 0.000 | 0.880 | 1.313 | 2.095 | 3.068 | 3.885 | 4.491 | 4.869 | 6.012 | 6.334 | 8.911 | 7.133 |
| 1990 | 0.000 | 0.571 | 1.263 | 2.055 | 2.894 | 3.657 | 4.766 | 5.818 | 6.371 | 6.966 | 7.625 | 9.770 |
| 1991 | 0.000 | 0.906 | 1.344 | 2.153 | 2.866 | 3.736 | 4.730 | 5.711 | 6.460 | 6.815 | 8.060 | 9.030 |
| 1992 | 0.000 | 1.033 | 1.271 | 1.831 | 2.615 | 3.509 | 4.614 | 5.466 | 6.141 | 6.864 | 8.164 | 9.189 |
| 1993 | 0.000 | 0.761 | 1.110 | 1.666 | 2.312 | 3.143 | 3.754 | 4.723 | 5.492 | 6.704 | 7.704 | 8.131 |
| 1994 | 0.000 | 0.805 | 1.250 | 1.586 | 2.163 | 3.058 | 3.765 | 4.219 | 4.854 | 6.268 | 6.082 | 7.846 |
| 1995 | 0.000 | 0.671 | 1.132 | 1.806 | 2.296 | 3.038 | 3.941 | 4.796 | 5.389 | 7.348 | 8.573 | 8.781 |
| 1996 | 0.000 | 0.896 | 1.336 | 1.795 | 2.353 | 3.057 | 3.665 | 5.205 | 6.296 | 8.502 | 9.561 | 11.422 |
| 1997 | 0.000 | 0.915 | 1.388 | 1.938 | 2.446 | 3.288 | 3.976 | 5.101 | 7.763 | 10.058 | 6.737 | 11.915 |
| 1998 | 0.000 | 0.867 | 1.103 | 1.720 | 2.361 | 3.144 | 4.219 | 5.159 | 5.640 | 8.615 | 8.833 | 12.063 |
| 1999 | 0.000 | 0.806 | 1.193 | 1.682 | 2.419 | 3.245 | 4.288 | 5.659 | 7.057 | 9.939 | 9.943 | 10.000 |
| 2000 | 0.000 | 0.757 | 1.247 | 1.796 | 2.478 | 3.166 | 4.168 | 5.412 | 5.745 | 9.003 | 9.821 | 10.000 |
| 2001 | 0.105 | 0.453 | 1.039 | 1.987 | 2.929 | 3.734 | 4.775 | 6.532 | 8.118 | 8.539 | 9.026 | 10.788 |
| 2002 | 0.062 | 0.280 | 0.931 | 1.592 | 2.528 | 3.714 | 4.829 | 6.328 | 6.936 | 8.663 | 10.872 | 11.081 |
| 2003 | 0.000 | 0.590 | 0.977 | 1.536 | 2.376 | 3.528 | 4.780 | 6.289 | 7.427 | 9.281 | 10.090 | 8.875 |
| 2004 | 0.000 | 0.475 | 0.873 | 1.621 | 2.210 | 3.125 | 4.290 | 6.509 | 7.369 | 8.699 | 9.077 | 12.027 |
| 2005 | 0.000 | 0.391 | 0.955 | 1.439 | 2.152 | 2.801 | 4.087 | 5.479 | 5.956 | 9.216 | 14.277 | 14.277 |
| 2006 | 0.309 | 0.654 | 0.931 | 1.722 | 2.180 | 3.101 | 3.715 | 4.680 | 5.186 | 9.121 | 9.906 | 10.851 |
| 2007 | 0.242 | 0.653 | 0.943 | 1.569 | 2.519 | 2.965 | 3.928 | 4.565 | 6.282 | 7.352 | 10.195 | 13.091 |
| 2008 | 0.127 | 0.423 | 1.184 | 1.692 | 2.308 | 3.258 | 3.909 | 4.920 | 5.572 | 6.023 | 9.366 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

Table 9. Small mobile gear (TC 1-3) age-disaggregated catch rates (t/hr X 100) for the Western Component (4Xopqrs+5), 1982-2008, calculated using the area-weighting factor. Catch rates for 2008 represent a partial year (Jan. 1 to Aug. 31).

| Age 3 |  |  |  |  |  |  | Age 4 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Age 5 | Age 6 | Age 7 | Age 8 |  |  |  |
| 1982 | 1.73618 | 1.05659 | 0.25010 | 0.71585 | 0.63833 | 0.34690 |  |
| 1983 | 1.63234 | 4.79889 | 0.83825 | 0.12018 | 0.19019 | 0.19183 |  |
| 1984 | 0.39640 | 2.20206 | 3.57016 | 0.63775 | 0.11518 | 0.18886 |  |
| 1985 | 0.16652 | 0.59705 | 1.89335 | 2.17520 | 0.31140 | 0.02630 |  |
| 1986 | 0.21737 | 1.60704 | 1.30413 | 1.51837 | 0.97958 | 0.08333 |  |
| 1987 | 0.14791 | 0.88466 | 1.91960 | 0.94589 | 0.83299 | 0.50974 |  |
| 1988 | 0.20501 | 0.58459 | 0.95114 | 1.15268 | 0.42856 | 0.36128 |  |
| 1989 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |  |
| 1990 | 0.85353 | 1.12637 | 1.41492 | 0.62373 | 0.23423 | 0.07713 |  |
| 1991 | 0.60288 | 1.68167 | 1.30591 | 1.03489 | 0.25098 | 0.12055 |  |
| 1992 | 1.06604 | 2.50417 | 1.26940 | 0.33478 | 0.09245 | 0.02818 |  |
| 1993 | 0.47819 | 1.87069 | 1.60049 | 0.59758 | 0.13088 | 0.03957 |  |
| 1994 | 0.27297 | 0.65252 | 1.18595 | 0.94482 | 0.36754 | 0.12473 |  |
| 1995 | 0.70258 | 1.07739 | 1.64714 | 0.95527 | 0.33871 | 0.07313 |  |
| 1996 | 0.51068 | 2.61485 | 1.79521 | 0.89458 | 0.39270 | 0.06122 |  |
| 1997 | 0.21472 | 1.28138 | 2.19496 | 0.77278 | 0.17993 | 0.03050 |  |
| 1998 | 0.15145 | 0.72029 | 1.13840 | 0.89502 | 0.16216 | 0.02476 |  |
| 1999 | 0.08221 | 0.68238 | 0.81977 | 0.45543 | 0.11994 | 0.01135 |  |
| 2000 | 0.95839 | 0.64343 | 0.80586 | 0.33650 | 0.10960 | 0.01981 |  |
| 2001 | 0.57027 | 1.29688 | 0.66726 | 0.30497 | 0.06890 | 0.01180 |  |
| 2002 | 0.22846 | 1.41125 | 1.94357 | 0.59130 | 0.14948 | 0.02355 |  |
| 2003 | 0.17170 | 2.10031 | 1.93918 | 0.54688 | 0.08971 | 0.01160 |  |
| 2004 | 0.24096 | 0.71439 | 2.31454 | 0.64809 | 0.07471 | 0.00648 |  |
| 2005 | 0.04392 | 1.32878 | 1.23908 | 1.58273 | 0.11223 | 0.00610 |  |
| 2006 | 0.03909 | 0.32913 | 1.07879 | 0.48413 | 0.24977 | 0.02069 |  |
| 2007 | 0.18010 | 1.03520 | 1.14080 | 1.49226 | 0.44718 | 0.05814 |  |
| 2008 | 0.17069 | 0.39796 | 0.91993 | 0.86266 | 0.48596 | 0.07581 |  |
|  |  |  |  |  |  |  |  |

Table 10. DFO summer research vessel survey age-disaggregated numbers per tow for the Western Component, 1984-2008.

|  | Age3 | Age4 | Age5 | Age6 | Age7 | Age8 |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: |
|  |  |  |  |  |  |  |
| 1984 | 0.545 | 0.951 | 3.308 | 0.913 | 0.097 | 0.284 |
| 1985 | 0.101 | 0.498 | 2.844 | 3.613 | 0.747 | 0.000 |
| 1986 | 1.468 | 1.929 | 1.599 | 3.027 | 1.821 | 0.072 |
| 1987 | 0.064 | 0.633 | 1.851 | 1.119 | 2.268 | 1.159 |
| 1988 | 1.651 | 2.277 | 6.218 | 5.278 | 4.043 | 1.984 |
| 1989 | 0.098 | 0.488 | 1.358 | 1.957 | 1.868 | 0.568 |
| 1990 | 15.197 | 6.864 | 10.383 | 2.456 | 0.619 | 0.755 |
| 1991 | 1.872 | 1.656 | 2.877 | 2.862 | 0.890 | 0.800 |
| 1992 | 0.364 | 0.989 | 1.341 | 1.061 | 0.223 | 0.143 |
| 1993 | 11.941 | 8.135 | 4.141 | 1.815 | 0.514 | 0.016 |
| 1994 | 0.301 | 1.086 | 2.306 | 1.980 | 0.784 | 0.219 |
| 1995 | 1.501 | 1.216 | 1.957 | 0.986 | 0.297 | 0.050 |
| 1996 | 1.142 | 12.519 | 10.772 | 3.475 | 1.531 | 0.133 |
| 1997 | 0.351 | 0.477 | 1.616 | 0.763 | 0.081 | 0.090 |
| 1998 | 0.126 | 0.306 | 0.616 | 0.609 | 0.143 | 0.000 |
| 1999 | 0.538 | 0.849 | 0.492 | 0.378 | 0.271 | 0.000 |
| 2000 | 0.480 | 0.439 | 0.795 | 0.216 | 0.000 | 0.029 |
| 2001 | 6.976 | 1.824 | 0.652 | 0.177 | 0.093 | 0.022 |
| 2002 | 1.583 | 0.731 | 0.580 | 0.200 | 0.106 | 0.024 |
| 2003 | 0.904 | 6.055 | 2.146 | 0.491 | 0.021 | 0.024 |
| 2004 | 2.462 | 1.438 | 3.659 | 1.347 | 0.313 | 0.000 |
| 2005 | 0.082 | 1.228 | 1.349 | 2.412 | 0.419 | 0.000 |
| 2006 | 0.896 | 10.378 | 22.111 | 8.642 | 3.219 | 0.201 |
| 2007 | 0.068 | 0.751 | 3.244 | 3.763 | 0.668 | 0.108 |
| 2008 | 0.210 | 0.489 | 4.298 | 5.222 | 2.008 | 0.134 |
|  |  |  |  |  |  |  |

Table 11. Beginning of year population abundance numbers (000's) for pollock in the Western Component from the Base VPA model formulation with 2005-2008 excluded from the CPUE series, using bootstrap bias adjusted population abundance.

| Year | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11 | Age 12 | Age 13 |
| :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 1982 | 16664 | 20867 | 4653 | 1119 | 2248 | 1991 | 947 | 404 | 87 | 102 | 34 | 1 |
| 1983 | 9119 | 13557 | 15625 | 2597 | 583 | 920 | 881 | 396 | 200 | 31 | 54 | 16 |
| 1984 | 11558 | 7425 | 9943 | 9230 | 1361 | 317 | 472 | 460 | 200 | 111 | 10 | 27 |
| 1985 | 7287 | 9459 | 5745 | 6492 | 5088 | 697 | 183 | 253 | 274 | 127 | 74 | 6 |
| 1986 | 7818 | 5962 | 7569 | 4144 | 3694 | 2250 | 278 | 116 | 118 | 136 | 49 | 34 |
| 1987 | 11224 | 6400 | 4735 | 4928 | 2372 | 1834 | 1057 | 149 | 62 | 63 | 74 | 26 |
| 1988 | 8603 | 9185 | 5146 | 3311 | 2580 | 1151 | 799 | 428 | 61 | 35 | 38 | 36 |
| 1989 | 12062 | 7027 | 7137 | 3323 | 1702 | 970 | 479 | 276 | 135 | 30 | 16 | 13 |
| 1990 | 13888 | 9791 | 5404 | 4465 | 1708 | 877 | 381 | 260 | 111 | 52 | 19 | 7 |
| 1991 | 10304 | 11328 | 7316 | 3433 | 2204 | 620 | 335 | 157 | 90 | 47 | 22 | 7 |
| 1992 | 5769 | 8384 | 8361 | 4283 | 1465 | 568 | 199 | 134 | 78 | 30 | 16 | 9 |
| 1993 | 5556 | 4682 | 5738 | 4444 | 2029 | 597 | 186 | 54 | 25 | 11 | 12 | 3 |
| 1994 | 8927 | 4545 | 3337 | 2915 | 1742 | 644 | 206 | 70 | 20 | 11 | 3 | 4 |
| 1995 | 6010 | 7263 | 3487 | 2125 | 1201 | 407 | 93 | 23 | 6 | 3 | 2 | 1 |
| 1996 | 3958 | 4899 | 5709 | 2371 | 892 | 381 | 75 | 20 | 4 | 2 | 2 | 1 |
| 1997 | 3531 | 3228 | 3829 | 3819 | 1305 | 309 | 86 | 13 | 3 | 3 | 1 | 1 |
| 1998 | 3356 | 2886 | 2506 | 2326 | 1648 | 375 | 62 | 23 | 7 | 2 | 1 | 1 |
| 1999 | 5904 | 2742 | 2157 | 1309 | 689 | 240 | 39 | 9 | 4 | 4 | 1 | 1 |
| 2000 | 6749 | 4822 | 2164 | 1319 | 517 | 186 | 44 | 13 | 4 | 2 | 1 | 1 |
| 2001 | 10107 | 5448 | 3424 | 1409 | 551 | 140 | 30 | 12 | 5 | 3 | 2 | 1 |
| 2002 | 5511 | 8261 | 4158 | 2072 | 642 | 172 | 34 | 12 | 6 | 2 | 1 | 1 |
| 2003 | 12351 | 4506 | 6591 | 2696 | 740 | 157 | 29 | 10 | 5 | 4 | 1 | 1 |
| 2004 | 7111 | 10110 | 3589 | 4226 | 1020 | 153 | 23 | 8 | 4 | 3 | 2 | 1 |
| 2005 | 6295 | 5820 | 8121 | 2450 | 1784 | 220 | 21 | 8 | 3 | 2 | 1 | 1 |
| 2006 | 1253 | 5153 | 4732 | 5890 | 1325 | 433 | 31 | 6 | 2 | 2 | 1 | 1 |
| 2007 | 1488 | 1025 | 4192 | 3735 | 4340 | 767 | 160 | 10 | 2 | 2 | 1 | 1 |
| 2008 |  | 1214 | 777 | 3102 | 2655 | 2993 | 421 | 106 | 5 | 1 | 1 | 1 |

Table 12. Bias adjusted fishing mortality rate for pollock in the Western Component from the Base VPA model formulation.

| Year | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Ag | Age 12 | 13 | 4-9 F | 6-9 F | Landings |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1982 | 0.006 | 0.089 | 0.383 | 0.452 | 0.694 | 0.616 | 0.673 | 0.501 | 0.834 | 0.440 | 0.539 | 0.000 | 0.521 | 0.648 | 18347 |
| 1983 | 0.005 | 0.110 | 0.326 | 0.446 | 0.410 | 0.468 | 0.449 | 0.482 | 0.391 | 0.942 | 0.476 | 0.000 | 0.358 | 0.452 | 16448 |
| 1984 | 0.000 | 0.057 | 0.226 | 0.396 | 0.469 | 0.351 | 0.422 | 0.318 | 0.253 | 0.203 | 0.285 | 0.000 | 0.321 | 0.419 | 15291 |
| 1985 | 0.001 | 0.023 | 0.127 | 0.364 | 0.616 | 0.718 | 0.256 | 0.566 | 0.504 | 0.763 | 0.578 | 0.000 | 0.375 | 0.615 | 19511 |
| 1986 | 0.000 | 0.030 | 0.229 | 0.358 | 0.500 | 0.555 | 0.423 | 0.426 | 0.418 | 0.408 | 0.417 | 0.000 | 0.359 | 0.515 | 17520 |
| 1987 | 0.000 | 0.018 | 0.158 | 0.447 | 0.523 | 0.631 | 0.704 | 0.693 | 0.357 | 0.311 | 0.529 | 0.000 | 0.411 | 0.600 | 16460 |
| 1988 | 0.002 | 0.052 | 0.237 | 0.466 | 0.778 | 0.676 | 0.861 | 0.954 | 0.501 | 0.581 | 0.876 | 0.000 | 0.495 | 0.783 | 17899 |
| 1989 | 0.009 | 0.063 | 0.269 | 0.465 | 0.463 | 0.734 | 0.4 | 0.7 | 0.745 | 0.249 | 0.690 | 0.000 | 0.386 | 0.553 | 3724 |
| 1990 | 0.004 | 0.091 | 0.254 | 0.506 | 0.813 | 0.762 | 0.689 | 0.863 | 0.659 | 0.665 | 0.785 | 0.000 | 0.472 | 0.789 | 5595 |
| 1991 | 0.006 | 0.104 | 0.335 | 0.652 | 1.157 | 0.935 | 0.718 | 0.492 | 0.888 | 0.877 | 0.675 | 0.000 | 0.579 | 1.039 | 18602 |
| 1992 | 0.009 | 0.179 | 0.432 | 0.547 | 0.698 | 0.918 | 1.113 | 1.494 | 1.775 | 0.737 | 1.490 | 0.000 | 0.528 | 0.831 | 16639 |
| 1993 | 0.001 | 0.139 | 0.477 | 0.736 | 0.947 | 0.865 | 0.781 | 0.799 | 0.624 | 1.082 | 0.786 | 0.000 | 0.662 | 0.916 | 14410 |
| 1994 | 0.006 | 0.065 | 0.251 | 0.687 | 1.253 | 1.734 | 1.992 | 2.275 | 1.530 | 1.571 | 0.905 | 0.000 | 0.753 | 1.453 | 10836 |
| 1995 | 0.004 | 0.041 | 0.186 | 0.668 | 0.947 | 1.498 | 1.323 | 1.647 | 1.077 | 0.415 | 0.407 | 0.000 | 0.542 | 1.107 | 7144 |
| 1996 | 0.004 | 0.046 | 0.202 | 0.398 | 0.859 | 1.292 | 1.565 | 1.604 | 0.104 | 0.042 | 0.438 | 0.000 | 0.371 | 1.029 | 6441 |
| 1997 | 0.002 | 0.053 | 0.298 | 0.640 | 1.047 | 1.412 | 1.128 | 0.462 | 0.132 | 0.478 | 0.049 | 0.000 | 0.587 | 1.112 | 9759 |
| 1998 | 0.002 | 0.091 | 0.450 | 1.017 | 1.726 | 2.068 | 1.674 | 1.458 | 0.403 | 0.475 | 0.107 | 0.000 | 1.045 | 1.783 | 10534 |
| 1999 | 0.002 | 0.036 | 0.291 | 0.729 | 1.109 | 1.489 | 0.923 | 0.647 | 0.354 | 0.882 | 0.000 | 0.000 | 0.618 | 1.190 | 4760 |
| 2000 | 0.014 | 0. | 0.229 | 0 | 1.107 | 1.623 | 1.097 | 0.772 | 0.285 | 0.086 | 0.000 | 0.000 | 0.546 | 227 | 768 |
| 20 | 0.002 | 0.070 | 0.302 | 0.585 | 0.962 | 1.209 | 0.692 | 0.531 | 0.513 | 0.331 | 0.427 | 0.000 | 0.465 | 0.991 | 5400 |
| 2002 | 0.001 | 0.026 | 0.233 | 0.829 | 1.208 | 1.566 | 0.986 | 0.730 | 0.271 | 0.253 | 0.185 | 0.000 | 0.533 | 1.264 | 6485 |
| 2003 | 0.000 | 0.027 | 0.245 | 0.772 | 1.377 | 1.705 | 1.105 | 0.850 | 0.305 | 0.541 | 0.198 | 0.000 | 0.491 | 1.418 | 7839 |
| 2004 | 0.000 | 0.018 | 0.178 | 0.662 | 1.333 | 1.770 | 0.900 | 0.877 | 0.687 | 0.669 | 0.352 | 0.014 | 0.565 | 1.377 | 8012 |
| 2005 | 0.000 | 0.006 | 0.113 | 0.399 | 1.208 | 1.742 | 1.111 | 1.024 | 0.235 | 0.006 | 0.007 | 0.000 | 0.355 | 1.264 | 6928 |
| 2006 | 0.001 | 0.005 | 0.032 | 0.097 | 0.320 | 0.768 | 0.953 | 0.799 | 0.094 | 0.026 | 0.002 | 0.000 | 0.122 | 0.441 | 3465 |
| 2007 | 0.002 | 0.059 | 0.079 | 0.119 | 0.154 | 0.338 | 0.191 | 0.322 | 0.365 | 0.200 | 0.006 | 0.000 | 0.131 | 0.182 | 4668 |
| 2008 | 0.006 | 0.052 | 0.249 | 0.140 | 0.196 | 0.111 | 0.116 | 0.118 | 0.143 | 0.077 | 0.000 | 0.000 | 0.153 | 0.148 | 3613 |

Table 13. Beginning of year biomass ( t ) for pollock in the Western Component from the Base VPA formulation using the bootstrap bias adjusted population abundance at the beginning of 2008.

| Year | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 Age 10 |  | Age 11 | Age 1 | ge 13 | $2+$ | $3+$ | 4+ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1982 | 4728 | 16923 | 7877 | 3344 | 8585 | 8926 | 4930 | 2405 | 602 | 831 | 325 | 11 | 59487 | 54758 | 37835 |
| 1983 | 2765 | 16745 | 25936 | 7659 | 2268 | 4265 | 4574 | 2426 | 1345 | 248 | 471 | 175 | 68878 | 66113 | 49368 |
| 1984 | 4163 | 7010 | 25999 | 25196 | 5046 | 1539 | 2625 | 2725 | 1328 | 802 | 89 | 271 | 76793 | 72630 | 65620 |
| 1985 | 2353 | 7630 | 13219 | 18824 | 16953 | 2918 | 1042 | 1686 | 1830 | 926 | 610 | 63 | 68054 | 65701 | 58071 |
| 1986 | 3308 | 5364 | 12167 | 12995 | 13035 | 9204 | 1389 | 733 | 852 | 983 | 404 | 345 | 60780 | 57472 | 52108 |
| 1987 | 2079 | 4106 | 8918 | 12585 | 7878 | 7551 | 4985 | 827 | 416 | 465 | 562 | 256 | 50628 | 48549 | 44443 |
| 1988 | 4921 | 6392 | 7019 | 8953 | 8786 | 4448 | 3702 | 2301 | 374 | 264 | 303 | 332 | 47795 | 42875 | 36483 |
| 1989 | 4413 | 5271 | 13565 | 8931 | 5901 | 4013 | 2164 | 1513 | 824 | 241 | 124 | 125 | 47084 | 42672 | 37401 |
| 1990 | 3524 | 6426 | 7148 | 12430 | 5722 | 3773 | 1949 | 1450 | 718 | 365 | 180 | 59 | 43744 | 40220 | 33794 |
| 1991 | 3773 | 6686 | 8443 | 8295 | 7247 | 2579 | 1748 | 961 | 593 | 352 | 183 | 75 | 40935 | 37162 | 30476 |
| 1992 | 1907 | 6503 | 11489 | 8525 | 4646 | 2357 | 1014 | 792 | 522 | 226 | 138 | 92 | 38211 | 36304 | 29801 |
| 1993 | 2468 | 2620 | 6704 | 9787 | 5816 | 2167 | 867 | 294 | 158 | 79 | 97 | 30 | 31085 | 28617 | 25997 |
| 1994 | 2762 | 3151 | 3696 | 4714 | 4632 | 2216 | 819 | 333 | 116 | 69 | 23 | 42 | 22573 | 19811 | 16660 |
| 1995 | 1277 | 3498 | 4126 | 4179 | 3078 | 1414 | 396 | 110 | 35 | 26 | 13 | 9 | 18162 | 16885 | 13387 |
| 1996 | 792 | 3005 | 5949 | 4626 | 2363 | 1273 | 338 | 112 | 25 | 14 | 19 | 10 | 18524 | 17732 | 14727 |
| 1997 | 720 | 3144 | 5129 | 8030 | 3629 | 1079 | 371 | 81 | 27 | 20 | 14 | 11 | 22254 | 21534 | 18390 |
| 1998 | 1257 | 1743 | 2434 | 4691 | 4571 | 1397 | 279 | 122 | 54 | 23 | 12 | 11 | 16595 | 15337 | 13594 |
| 1999 | 1308 | 1665 | 2568 | 2392 | 1907 | 882 | 190 | 57 | 32 | 33 | 11 | 12 | 11056 | 9749 | 8084 |
| 2000 | 1779 | 3362 | 2616 | 2425 | 1431 | 684 | 214 | 72 | 32 | 25 | 12 | 10 | 12662 | 10884 | 7521 |
| 2001 | 3164 | 2860 | 5065 | 3314 | 1677 | 544 | 157 | 80 | 33 | 23 | 19 | 10 | 16948 | 13784 | 10924 |
| 2002 | 1419 | 4994 | 4878 | 4382 | 2119 | 732 | 188 | 83 | 49 | 23 | 15 | 11 | 18891 | 17472 | 12479 |
| 2003 | 2718 | 3192 | 7746 | 5664 | 2211 | 662 | 162 | 72 | 39 | 34 | 15 | 11 | 22526 | 19807 | 16615 |
| 2004 | 1459 | 5724 | 5131 | 8054 | 2780 | 595 | 130 | 54 | 29 | 27 | 19 | 10 | 24014 | 22555 | 16831 |
| 2005 | 1428 | 3474 | 10093 | 4631 | 4396 | 780 | 101 | 48 | 22 | 17 | 14 | 12 | 25015 | 23587 | 20113 |
| 2006 | 439 | 3616 | 6589 | 11342 | 3343 | 1383 | 136 | 30 | 17 | 17 | 15 | 13 | 26939 | 26501 | 22885 |
| 2007 | 332 | 717 | 6040 | 8183 | 11035 | 2677 | 658 | 52 | 13 | 16 | 16 | 11 | 29751 | 29419 | 28702 |
| 2008 | 2083 | 937 | 1043 | 6112 | 7607 | 10191 | 1851 | 536 | 33 | 10 | 13 | 14 | 30430 | 28347 | 27410 |

Table 14. Beginning of year population abundance numbers (000's) for pollock in the Western Component from the Framework VPA model formulation with 2005-2008 included from the CPUE series, using bootstrap bias adjusted population abundance.

| Year | Age 2 | Age 3 | Age 4 | Age5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11 | Age 12 | Age 13 |
| :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 1982 | 16664 | 20867 | 4653 | 1119 | 2248 | 1991 | 947 | 404 | 87 | 102 | 34 | 1 |
| 1983 | 9119 | 13557 | 15625 | 2597 | 583 | 920 | 881 | 396 | 200 | 31 | 54 | 16 |
| 1984 | 11558 | 7425 | 9943 | 9230 | 1361 | 317 | 472 | 460 | 200 | 111 | 10 | 27 |
| 1985 | 7287 | 9459 | 5745 | 6492 | 5088 | 697 | 183 | 253 | 274 | 127 | 74 | 6 |
| 1986 | 7818 | 5962 | 7569 | 4144 | 3694 | 2250 | 278 | 116 | 118 | 136 | 49 | 34 |
| 1987 | 11224 | 6400 | 4735 | 4928 | 2372 | 1834 | 1057 | 149 | 62 | 63 | 74 | 26 |
| 1988 | 8603 | 9185 | 5146 | 3311 | 2580 | 1151 | 799 | 428 | 61 | 35 | 38 | 36 |
| 1989 | 12062 | 7027 | 7137 | 3323 | 1702 | 970 | 479 | 276 | 135 | 30 | 16 | 13 |
| 1990 | 13888 | 9791 | 5404 | 4465 | 1708 | 877 | 381 | 260 | 111 | 52 | 19 | 7 |
| 1991 | 10304 | 11328 | 7316 | 3433 | 2204 | 620 | 335 | 157 | 90 | 47 | 22 | 7 |
| 1992 | 5769 | 8384 | 8361 | 4283 | 1465 | 568 | 199 | 134 | 78 | 30 | 16 | 9 |
| 1993 | 5556 | 4682 | 5738 | 4444 | 2029 | 597 | 186 | 54 | 25 | 11 | 12 | 3 |
| 1994 | 8927 | 4545 | 3337 | 2915 | 1742 | 644 | 206 | 70 | 20 | 11 | 3 | 4 |
| 1995 | 6010 | 7263 | 3487 | 2125 | 1201 | 407 | 93 | 23 | 6 | 3 | 2 | 1 |
| 1996 | 3958 | 4899 | 5709 | 2371 | 892 | 381 | 75 | 20 | 4 | 2 | 2 | 1 |
| 1997 | 3531 | 3228 | 3829 | 3819 | 1305 | 309 | 86 | 13 | 3 | 3 | 1 | 1 |
| 1998 | 3356 | 2886 | 2506 | 2326 | 1648 | 375 | 62 | 23 | 7 | 2 | 1 | 1 |
| 1999 | 5904 | 2742 | 2157 | 1309 | 689 | 240 | 39 | 9 | 4 | 4 | 1 | 1 |
| 2000 | 6743 | 4822 | 2164 | 1319 | 517 | 186 | 44 | 13 | 4 | 2 | 1 | 1 |
| 2001 | 10022 | 5443 | 3424 | 1409 | 551 | 140 | 30 | 12 | 5 | 3 | 2 | 1 |
| 2002 | 5236 | 8191 | 4154 | 2072 | 642 | 172 | 34 | 12 | 6 | 2 | 1 | 1 |
| 2003 | 10830 | 4281 | 6534 | 2693 | 740 | 157 | 29 | 10 | 5 | 4 | 1 | 1 |
| 2004 | 4626 | 8865 | 3404 | 4179 | 1018 | 153 | 23 | 8 | 4 | 3 | 2 | 1 |
| 2005 | 4283 | 3785 | 7102 | 2299 | 1746 | 218 | 21 | 8 | 3 | 2 | 1 | 1 |
| 2006 | 1838 | 3506 | 3066 | 5055 | 1202 | 403 | 30 | 6 | 2 | 2 | 1 | 1 |
| 2007 | 2336 | 1504 | 2844 | 2372 | 3657 | 667 | 135 | 8 | 2 | 2 | 1 | 1 |
| 2008 |  | 1908 | 1170 | 1998 | 1539 | 2434 | 339 | 86 | 4 | 1 | 1 | 1 |

Table 15. Bias adjusted fishing mortality rate for pollock in the Western Component from the Framework VPA model formulation with 2005-2008 included from the CPUE series.

| Year | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11 | Age 12 | Age 13 | 4-9 F | 6-9 F Landings |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1982 | 0.006 | 0.089 | 0.383 | 0.452 | 0.694 | 0.616 | 0.673 | 0.501 | 0.834 | 0.440 | 0.539 | 0.000 | 0.521 | 0.648 | 18347 |
| 1983 | 0.005 | 0.110 | 0.326 | 0.446 | 0.410 | 0.468 | 0.449 | 0.482 | 0.391 | 0.942 | 0.476 | 0.000 | 0.358 | 0.452 | 16448 |
| 1984 | 0.000 | 0.057 | 0.226 | 0.396 | 0.469 | 0.351 | 0.422 | 0.318 | 0.253 | 0.203 | 0.285 | 0.000 | 0.321 | 0.419 | 15291 |
| 1985 | 0.001 | 0.023 | 0.127 | 0.364 | 0.616 | 0.718 | 0.256 | 0.566 | 0.504 | 0.763 | 0.578 | 0.000 | 0.375 | 0.615 | 19511 |
| 1986 | 0.000 | 0.030 | 0.229 | 0.358 | 0.500 | 0.555 | 0.423 | 0.426 | 0.418 | 0.408 | 0.417 | 0.000 | 0.359 | 0.515 | 17520 |
| 1987 | 0.000 | 0.018 | 0.158 | 0.447 | 0.523 | 0.631 | 0.704 | 0.693 | 0.357 | 0.311 | 0.529 | 0.000 | 0.411 | 0.600 | 16460 |
| 1988 | 0.002 | 0.052 | 0.237 | 0.466 | 0.778 | 0.676 | 0.861 | 0.954 | 0.501 | 0.581 | 0.876 | 0.000 | 0.495 | 0.783 | 17899 |
| 1989 | 0.009 | 0.063 | 0.269 | 0.465 | 0.463 | 0.734 | 0.410 | 0.712 | 0.745 | 0.249 | 0.690 | 0.000 | 0.386 | 0.553 | 13724 |
| 1990 | 0.004 | 0.091 | 0.254 | 0.506 | 0.813 | 0.762 | 0.689 | 0.863 | 0.659 | 0.665 | 0.785 | 0.000 | 0.472 | 0.789 | 15595 |
| 1991 | 0.006 | 0.104 | 0.335 | 0.652 | 1.157 | 0.935 | 0.718 | 0.492 | 0.888 | 0.877 | 0.675 | 0.000 | 0.579 | 1.039 | 18602 |
| 1992 | 0.009 | 0.179 | 0.432 | 0.547 | 0.698 | 0.918 | 1.113 | 1.494 | 1.775 | 0.737 | 1.490 | 0.000 | 0.528 | 0.831 | 16639 |
| 1993 | 0.001 | 0.139 | 0.477 | 0.736 | 0.947 | 0.865 | 0.781 | 0.799 | 0.624 | 1.082 | 0.786 | 0.000 | 0.662 | 0.916 | 14410 |
| 1994 | 0.006 | 0.065 | 0.251 | 0.687 | 1.253 | 1.734 | 1.992 | 2.275 | 1.530 | 1.571 | 0.905 | 0.000 | 0.753 | 1.453 | 10836 |
| 1995 | 0.004 | 0.041 | 0.186 | 0.668 | 0.947 | 1.498 | 1.323 | 1.647 | 1.077 | 0.415 | 0.407 | 0.000 | 0.542 | 1.107 | 7144 |
| 1996 | 0.004 | 0.046 | 0.202 | 0.398 | 0.859 | 1.292 | 1.565 | 1.604 | 0.104 | 0.042 | 0.438 | 0.000 | 0.371 | 1.029 | 6441 |
| 1997 | 0.002 | 0.053 | 0.298 | 0.640 | 1.047 | 1.412 | 1.128 | 0.462 | 0.132 | 0.478 | 0.049 | 0.000 | 0.587 | 1.112 | 9759 |
| 1998 | 0.002 | 0.091 | 0.450 | 1.017 | 1.726 | 2.068 | 1.674 | 1.458 | 0.403 | 0.475 | 0.107 | 0.000 | 1.045 | 1.783 | 10534 |
| 1999 | 0.002 | 0.036 | 0.291 | 0.729 | 1.109 | 1.489 | 0.923 | 0.647 | 0.354 | 0.882 | 0.000 | 0.000 | 0.618 | 1.190 | 4760 |
| 2000 | 0.014 | 0.142 | 0.229 | 0.673 | 1.107 | 1.623 | 1.097 | 0.772 | 0.285 | 0.086 | 0.000 | 0.000 | 0.546 | 1.227 | 4768 |
| 2001 | 0.002 | 0.070 | 0.302 | 0.585 | 0.962 | 1.209 | 0.692 | 0.531 | 0.513 | 0.331 | 0.427 | 0.000 | 0.465 | 0.991 | 5400 |
| 2002 | 0.002 | 0.026 | 0.233 | 0.829 | 1.208 | 1.566 | 0.986 | 0.730 | 0.271 | 0.253 | 0.185 | 0.000 | 0.533 | 1.264 | 6485 |
| 2003 | 0.000 | 0.029 | 0.247 | 0.773 | 1.377 | 1.705 | 1.105 | 0.850 | 0.305 | 0.541 | 0.198 | 0.000 | 0.494 | 1.418 | 7839 |
| 2004 | 0.000 | 0.021 | 0.190 | 0.673 | 1.340 | 1.770 | 0.900 | 0.877 | 0.687 | 0.669 | 0.352 | 0.014 | 0.583 | 1.383 | 8012 |
| 2005 | 0.000 | 0.010 | 0.133 | 0.439 | 1.262 | 1.789 | 1.111 | 1.024 | 0.235 | 0.006 | 0.007 | 0.000 | 0.402 | 1.317 | 6928 |
| 2006 | 0.000 | 0.008 | 0.052 | 0.116 | 0.371 | 0.867 | 1.059 | 0.799 | 0.094 | 0.026 | 0.002 | 0.000 | 0.162 | 0.507 | 3465 |
| 2007 | 0.002 | 0.043 | 0.135 | 0.208 | 0.190 | 0.425 | 0.234 | 0.401 | 0.365 | 0.200 | 0.006 | 0.000 | 0.195 | 0.227 | 4668 |
| 2008 | 0.006 | 0.046 | 0.181 | 0.260 | 0.380 | 0.142 | 0.159 | 0.150 | 0.192 | 0.077 | 0 | 0 | 0.228 | 0.227 | 3613 |

Table 16. Beginning of year biomass (t) for pollock in the Western Component from the Framework VPA model formulation with 2005-2008 included from the CPUE series, using the bootstrap bias adjusted population abundance at the beginning of 2008.

| Year | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11 | Age 12 | Age 13 | 2+ | 3+ | 4+ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1982 | 4728 | 16923 | 7877 | 3344 | 8585 | 8926 | 4930 | 2405 | 602 | 831 | 325 | 11 | 59487 | 54758 | 37835 |
| 1983 | 2765 | 16745 | 25936 | 7659 | 2268 | 4265 | 4574 | 2426 | 1345 | 248 | 471 | 175 | 68878 | 66113 | 49368 |
| 1984 | 4163 | 7010 | 25999 | 25196 | 5046 | 1539 | 2625 | 2725 | 1328 | 802 | 89 | 271 | 76793 | 72630 | 65620 |
| 1985 | 2353 | 7630 | 13219 | 18824 | 16953 | 2918 | 1042 | 1686 | 1830 | 926 | 610 | 63 | 68054 | 65701 | 58071 |
| 1986 | 3308 | 5364 | 12167 | 12995 | 13035 | 9204 | 1389 | 733 | 852 | 983 | 404 | 345 | 60780 | 57472 | 52108 |
| 1987 | 2079 | 4106 | 8918 | 12585 | 7878 | 7551 | 4985 | 827 | 416 | 465 | 562 | 256 | 50628 | 48549 | 44443 |
| 1988 | 4921 | 6392 | 7019 | 8953 | 8786 | 4448 | 3702 | 2301 | 374 | 264 | 303 | 332 | 47795 | 42875 | 36483 |
| 1989 | 4413 | 5271 | 13565 | 8931 | 5901 | 4013 | 2164 | 1513 | 824 | 241 | 124 | 125 | 47084 | 42672 | 37401 |
| 1990 | 3524 | 6426 | 7148 | 12430 | 5722 | 3773 | 1949 | 1450 | 718 | 365 | 180 | 59 | 43744 | 40220 | 33794 |
| 1991 | 3773 | 6686 | 8443 | 8295 | 7247 | 2579 | 1748 | 961 | 593 | 352 | 183 | 75 | 40935 | 37162 | 30476 |
| 1992 | 1907 | 6503 | 11489 | 8525 | 4646 | 2357 | 1014 | 792 | 522 | 226 | 138 | 92 | 38211 | 36304 | 29801 |
| 1993 | 2468 | 2620 | 6704 | 9787 | 5816 | 2167 | 867 | 294 | 158 | 79 | 97 | 30 | 31085 | 28617 | 25997 |
| 1994 | 2762 | 3151 | 3696 | 4714 | 4632 | 2216 | 819 | 333 | 116 | 69 | 23 | 42 | 22573 | 19811 | 16660 |
| 1995 | 1277 | 3498 | 4126 | 4179 | 3078 | 1414 | 396 | 110 | 35 | 26 | 13 | 9 | 18162 | 16885 | 13387 |
| 1996 | 792 | 3005 | 5949 | 4626 | 2363 | 1273 | 338 | 112 | 25 | 14 | 19 | 10 | 18524 | 17732 | 14727 |
| 1997 | 720 | 3144 | 5129 | 8030 | 3629 | 1079 | 371 | 81 | 27 | 20 | 14 | 11 | 22254 | 21534 | 18390 |
| 1998 | 1257 | 1743 | 2434 | 4691 | 4571 | 1397 | 279 | 122 | 54 | 23 | 12 | 11 | 16595 | 15337 | 13594 |
| 1999 | 1308 | 1665 | 2568 | 2392 | 1907 | 882 | 190 | 57 | 32 | 33 | 11 | 12 | 11056 | 9749 | 8084 |
| 2000 | 1777 | 3362 | 2616 | 2425 | 1431 | 684 | 214 | 72 | 32 | 25 | 12 | 10 | 12661 | 10884 | 7521 |
| 2001 | 3137 | 2858 | 5065 | 3314 | 1677 | 544 | 157 | 80 | 33 | 23 | 19 | 10 | 16919 | 13782 | 10924 |
| 2002 | 1348 | 4952 | 4873 | 4382 | 2119 | 732 | 188 | 83 | 49 | 23 | 15 | 11 | 18774 | 17426 | 12474 |
| 2003 | 2384 | 3032 | 7679 | 5657 | 2211 | 662 | 162 | 72 | 39 | 34 | 15 | 11 | 21957 | 19574 | 16542 |
| 2004 | 949 | 5019 | 4868 | 7965 | 2773 | 595 | 130 | 54 | 29 | 27 | 19 | 10 | 22439 | 21490 | 16471 |
| 2005 | 972 | 2260 | 8826 | 4346 | 4303 | 773 | 101 | 48 | 22 | 17 | 14 | 12 | 21691 | 20719 | 18460 |
| 2006 | 644 | 2460 | 4270 | 9734 | 3033 | 1287 | 129 | 30 | 17 | 17 | 15 | 13 | 21647 | 21003 | 18543 |
| 2007 | 521 | 1053 | 4097 | 5195 | 9298 | 2326 | 558 | 45 | 13 | 16 | 16 | 11 | 23150 | 22628 | 21575 |
| 2008 | 2083 | 1473 | 1570 | 3937 | 4410 | 8288 | 1491 | 435 | 27 | 10 | 13 | 14 | 23749 | 21666 | 20194 |

Table 17. Bias adjusted statistical properties of estimates for population abundance and survey calibration constants for pollock in the Western Component using the Base VPA model formulation.

| Age | Estimate | Bootstrap |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Standard Error | Relative Error | Bias | Relative Bias |
| Population Abundance |  |  |  |  |  |
| 3 | 1490 | 2629.071 | 1.765 | 508.457 | 0.341 |
| 4 | 653 | 541.956 | 0.830 | 120.051 | 0.184 |
| 5 | 2686 | 1889.991 | 0.704 | 305.659 | 0.114 |
| 6 | 2184 | 1266.327 | 0.580 | 223.894 | 0.103 |
| 7 | 2557 | 1075.138 | 0.420 | 155.701 | 0.061 |
| 8 | 365 | 212.140 | 0.581 | 33.861 | 0.093 |

## RV Survey Calibration Constants

 1984-2008 (Ages 3-8)| 3 | 0.00013 | 0.00002 | 0.16807 | 0.00000 | 0.01297 |
| :--- | :--- | :--- | :--- | :--- | :--- |
| 4 | 0.00038 | 0.00006 | 0.16248 | 0.00001 | 0.01445 |
| 5 | 0.00101 | 0.00017 | 0.16372 | 0.00001 | 0.00814 |
| 6 | 0.00156 | 0.00025 | 0.16011 | 0.00002 | 0.01381 |
| 7 | 0.00179 | 0.00028 | 0.15843 | 0.00003 | 0.01440 |
| 8 | 0.00147 | 0.00026 | 0.17909 | 0.00002 | 0.01605 |

## CPUE Calibration Constants

1982-2004 (Ages 3-8)

| 3 | 0.00000 | 0.00037 | 317.96456 | 0.00005 | 43.88887 |
| ---: | ---: | ---: | ---: | ---: | ---: |
| 4 | 0.00001 | 0.00191 | 227.03467 | 0.00027 | 31.80909 |
| 5 | 0.00009 | 0.00694 | 80.61210 | 0.00087 | 10.10988 |
| 6 | 0.00013 | 0.00156 | 12.37105 | 0.00032 | 2.55824 |
| 7 | 0.00008 | 0.00014 | 1.69131 | 0.00004 | 0.52339 |
| 8 | 0.00001 | 0.00001 | 0.79444 | 0.00000 | 0.15975 |

CPUE Power Coefficients
1982-2004 (Ages 3-8)

| 3 | 0.93254 | 0.33902 | 0.36354 | -0.00562 | -0.00603 |
| :--- | ---: | ---: | ---: | ---: | ---: |
| 4 | 0.88259 | 0.33401 | 0.37844 | -0.01243 | -0.01408 |
| 5 | 0.66181 | 0.27977 | 0.42274 | -0.00208 | -0.00314 |
| 6 | 0.59663 | 0.23519 | 0.39420 | -0.00056 | -0.00093 |
| 7 | 0.58581 | 0.16105 | 0.27492 | -0.00057 | -0.00098 |
| 8 | 0.81583 | 0.12645 | 0.15500 | 0.00452 | 0.00554 |

Table 18. Deterministic projection results for pollock in the Western Component from the Base VPA formulation using the bootstrap bias adjusted population abundance at the beginning of 2008.

| Projected | Populat $2$ | n Numb 3 | rs 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2008.67 | 4355 | 981 | 533 | 2380 | 1960 | 2402 | 331 | 85 | 4 | 1 | 1 | 1 |  |  |  |  |
| 2009.25 | 5000 | 3872 | 860 | 462 | 2030 | 1634 | 1984 | 275 | 70 | 4 | 1 | 1 |  |  |  |  |
| 2010.25 | 5000 | 4077 | 3036 | 656 | 337 | 1394 | 1095 | 1344 | 184 | 49 | 3 | 1 |  |  |  |  |
| Fishing Mortality |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |  |  |  |  |
| 2008.67 | 0.003 | 0.028 | 0.045 | 0.075 | 0.114 | 0.129 | 0.123 | 0.132 | 0.108 | 0.057 | 0.001 | 0.000 |  |  |  |  |
| 2009.25 | 0.004 | 0.043 | 0.070 | 0.115 | 0.176 | 0.200 | 0.190 | 0.203 | 0.166 | 0.087 | 0.001 | 0.000 |  |  |  |  |
| PR |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |  |  |  |  |
| 2008.67 | 0.02 | 0.22 | 0.35 | 0.58 | 0.88 | 1.00 | 0.95 | 1.02 | 0.83 | 0.44 | 0.01 | 0.00 |  |  |  |  |
| 2009.25 | 0.02 | 0.22 | 0.35 | 0.58 | 0.88 | 1.00 | 0.95 | 1.02 | 0.83 | 0.44 | 0.01 | 0.00 |  |  |  |  |
| BegWt |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |  |  |  |  |
| 2008.67 | 0.33 | 0.72 | 1.39 | 2.03 | 2.64 | 3.36 | 4.28 | 5.22 | 6.52 | 9.10 | 11.61 | 11.65 |  |  |  |  |
| 2009.25 | 0.33 | 0.72 | 1.39 | 2.03 | 2.64 | 3.36 | 4.28 | 5.22 | 6.52 | 9.10 | 11.61 | 11.65 |  |  |  |  |
| 2010.25 | 0.33 | 0.72 | 1.39 | 2.03 | 2.64 | 3.36 | 4.28 | 5.22 | 6.52 | 9.10 | 11.61 | 11.65 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2008.67 | 1437 | 711 | 742 | 4830 | 5183 | 8077 | 1419 | 444 | 27 | 9 | 12 | 12 | 22903 | 21466 | 20755 | 20013 |
| 2009.25 | 1650 | 2803 | 1197 | 938 | 5367 | 5496 | 8497 | 1435 | 458 | 32 | 10 | 10 | 27893 | 26243 | 23440 | 22243 |
| 2010.25 | 1650 | 2952 | 4226 | 1332 | 891 | 4689 | 4692 | 7015 | 1198 | 443 | 31 | 8 | 29126 | 27476 | 24524 | 20298 |
| Projected Catch Numbers |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |  |  |  |  |
| 2008.67 | 6 | 15 | 13 | 95 | 118 | 164 | 22 | 6 | 0 | 0 | 0 | 0 |  |  |  |  |
| 2009.25 | 18 | 149 | 53 | 46 | 297 | 269 | 312 | 46 | 10 | 0 | 0 | 0 |  |  |  |  |
| AvgWt |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |  |  |  |  |
| 2008.67 | 0.58 | 1.02 | 1.66 | 2.34 | 3.11 | 3.85 | 4.72 | 5.68 | 7.50 | 9.82 | 11.82 | 11.00 |  |  |  |  |
| 2009.25 | 0.58 | 1.02 | 1.66 | 2.34 | 3.11 | 3.85 | 4.72 | 5.68 | 7.50 | 9.82 | 11.82 | 11.00 |  |  |  |  |
| Projected Catch Biomass |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | $2+$ | $3+$ | $4+$ | $5+$ |
| 2008.67 | 4 | 15 | 22 | 223 | 367 | 632 | 102 | 34 | 2 | 0 | 0 | 0 | 1400 | 1396 | 1381 | 1359 |
| 2009.25 | 10 | 152 | 88 | 107 | 924 | 1037 | 1471 | 261 | 73 | 3 | 0 | 0 | 4126 | 4116 | 3964 | 3876 |

Table 19. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 4X from pollock-directed mobile gear trips.

| Species | Total Kept <br> $(\mathrm{t})$ | Total Discarded <br> $(\mathrm{t})$ | \% Kept | \% Discarded |
| :--- | :---: | :---: | :---: | :---: |
|  |  |  |  |  |
| POLLOCK | 172.099 | 0.000 | 92.20 | 0.00 |
| HADDOCK | 2.965 | 0.000 | 1.59 | 0.00 |
| COD(ATLANTIC) | 2.333 | 0.000 | 1.25 | 0.00 |
| WHITE HAKE | 0.450 | 0.000 | 0.24 | 0.00 |
| REDFISH | 0.481 | 0.005 | 0.26 | 0.00 |
| WINTER FLOUNDER | 0.052 | 0.000 | 0.03 | 0.00 |
| MONKFISH | 0.047 | 0.000 | 0.03 | 0.00 |
| WITCH FLOUNDER | 0.030 | 0.000 | 0.02 | 0.00 |
| CUSK | 0.020 | 0.000 | 0.01 | 0.00 |
| AMERICAN PLAICE | 0.005 | 0.000 | 0.00 | 0.00 |
| AMERICAN LOBSTER | 0.000 | 0.532 | 0.00 | 0.29 |
| SPINY DOGFISH | 0.000 | 3.584 | 0.00 | 1.92 |
| THORNY SKATE | 0.000 | 0.059 | 0.00 | 0.03 |
| LONGHORN SCULPIN | 0.000 | 0.001 | 0.00 | 0.00 |
| ASTEROIDEA | 0.000 | 0.001 | 0.00 | 0.00 |
| STRIPED ATLANTIC WOLFFISH | 0.005 | 0.000 | 0.00 | 0.00 |
| UNIDENTIFIED SKATES | 0.000 | 0.035 | 0.00 | 0.02 |
| SHAD AMERICAN | 0.042 | 0.175 | 0.02 | 0.09 |
| LITTLE SKATE | 0.000 | 0.001 | 0.00 | 0.00 |
| HALIBUT | 0.027 | 0.000 | 0.01 | 0.00 |
| BASKING SHARK | 0.000 | 3.629 | 0.00 | 1.94 |
| BARNDOOR SKATE | 0.000 | 0.081 | 0.00 | 0.04 |
| TOTAL | $\mathbf{1 7 8 . 5 5 6}$ | $\mathbf{8 . 1 0 3}$ | $\mathbf{9 5 . 6 6}$ | 4.34 |
|  |  |  |  |  |

Table 20. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 5Z from pollock-directed mobile gear trips.

| Species | Total Kept Total Discarded |  |  |  |
| :--- | :---: | :---: | :---: | :---: |
| $(\mathrm{t})$ | \% Kept | \% Discarded |  |  |
|  |  |  |  |  |
| POLLOCK | 238.458 | 0.010 | 90.65 | 0.00 |
| HADDOCK | 19.151 | 0.001 | 7.28 | 0.00 |
| COD | 2.936 | 0.000 | 1.12 | 0.00 |
| REDFISH | 0.157 | 0.000 | 0.06 | 0.00 |
| YELLOWTAIL FLOUNDER | 0.045 | 0.000 | 0.02 | 0.00 |
| STRIPED ATLANTIC WOLFFISH | 0.070 | 0.000 | 0.03 | 0.00 |
| AMERICAN PLAICE | 0.013 | 0.001 | 0.00 | 0.00 |
| MONKFISH | 0.008 | 0.000 | 0.00 | 0.00 |
| WHITE HAKE | 0.004 | 0.000 | 0.00 | 0.00 |
| WINTER FLOUNDER | 0.003 | 0.000 | 0.00 | 0.00 |
| THORNY SKATE | 0.002 | 0.053 | 0.00 | 0.02 |
| SPINY DOGFISH | 0.000 | 1.927 | 0.00 | 0.73 |
| AMERICAN LOBSTER | 0.000 | 0.113 | 0.00 | 0.04 |
| BARNDOOR SKATE | 0.000 | 0.055 | 0.00 | 0.02 |
| WINTER SKATE | 0.000 | 0.038 | 0.00 | 0.01 |
| SEA RAVEN | 0.000 | 0.009 | 0.00 | 0.00 |
| SHORT-FIN SQUID | 0.000 | 0.003 | 0.00 | 0.00 |
| LONGHORN SCULPIN | 0.000 | 0.002 | 0.00 | 0.00 |
| UNIDENTIFIED SKATES) | 0.000 | 0.002 | 0.00 | 0.00 |
| TOTAL | $\mathbf{2 6 0 . 8 4 7}$ | $\mathbf{2 . 2 1 4}$ | $\mathbf{9 9 . 1 6}$ | $\mathbf{0 . 8 4}$ |
|  |  |  |  |  |

Table 21. Kept versus discarded bycatch reported for 2007-2008 combined observed trips in 4W test fisheries from pollock-directed mobile gear trips.

| Species | Total Kept <br> $(\mathrm{t})$ | Total Discarded <br> $(\mathrm{t})$ | \% Kept | \% Discarded |
| :--- | :---: | :---: | :---: | :---: |
|  |  |  |  |  |
| POLLOCK | 664.898 | 0.272 | 97.52 | 0.04 |
| REDFISH | 5.991 | 0.126 | 0.88 | 0.02 |
| COD | 1.044 | 0.002 | 0.15 | 0.00 |
| HADDOCK | 1.026 | 0.001 | 0.15 | 0.00 |
| WHITE HAKE | 0.687 | 0.073 | 0.10 | 0.01 |
| WITCH FLOUNDER | 0.110 | 0.082 | 0.02 | 0.01 |
| MONKFISH | 0.095 | 0.001 | 0.01 | 0.00 |
| CUSK | 0.048 | 0.010 | 0.01 | 0.00 |
| HALIBUT | 0.037 | 0.085 | 0.01 | 0.01 |
| STRIPED ATLANTIC WOLFFISH | 0.011 | 0.000 | 0.00 | 0.00 |
| RED HAKE | 0.004 | 0.000 | 0.00 | 0.00 |
| AMERICAN PLAICE | 0.005 | 0.000 | 0.00 | 0.00 |
| SPONGES | 0.000 | 6.107 | 0.00 | 0.90 |
| UNIDENTIFIED SEALS | 0.000 | 0.454 | 0.00 | 0.07 |
| ATLANTIC TORPEDO | 0.000 | 0.215 | 0.00 | 0.03 |
| LITTLE SKATE | 0.000 | 0.036 | 0.00 | 0.01 |
| AMERICAN LOBSTER | 0.000 | 0.133 | 0.00 | 0.02 |
| THORNY SKATE | 0.000 | 0.018 | 0.00 | 0.00 |
| BARNDOOR SKATE | 0.010 | 0.084 | 0.00 | 0.01 |
| SHAD AMERICAN | 0.000 | 0.004 | 0.00 | 0.00 |
| WINTER SKATE | 0.000 | 0.002 | 0.00 | 0.00 |
| SHORT-FIN SQUID | 0.000 | 0.026 | 0.00 | 0.00 |
| SPINY DOGFISH | 0.000 | 0.007 | 0.00 | 0.00 |
| SPIDER CRAB | 0.000 | 0.001 | 0.00 | 0.00 |
| LUMPFISH | 0.000 | 0.001 | 0.00 | 0.00 |
| TURBOT | 0.002 | 0.000 | 0.00 | 0.00 |
| SWORDFISH | 0.000 | 0.102 | 0.00 | 0.01 |
| SILVER HAKE | 0.001 | 0.001 | 0.00 | 0.00 |
| LONGHORN SCULPIN | 0.000 | 0.002 | 0.00 | 0.00 |
| UNIDENTIFIED HAKE | 0.005 | 0.000 | 0.00 | 0.00 |
| FOURSPOT FLOUNDER | 0.001 | 0.000 | 0.00 | 0.00 |
| LARGE-EYED ARGENTINE | 0.001 | 0.000 | 0.00 | 0.00 |
| TOTAL | $\mathbf{6 7 3 . 9 7 6}$ | $\mathbf{7 . 8 4 5}$ | 98.85 | $\mathbf{1 . 1 5}$ |
|  |  |  |  |  |
|  |  |  |  |  |

Table 22. Kept versus discarded bycatch reported for 2008 in 4X from observed pollock-directed gillnet trips.

| Species | Total Kept <br> $(\mathrm{t})$ | Total Discarded <br> $(\mathrm{t})$ | \% Kept | \% Discarded |
| :--- | :---: | :---: | :---: | :---: |
|  |  |  |  |  |
| POLLOCK | 13.669 | 0.165 | 61.15 | 0.74 |
| WHITE HAKE | 3.263 | 0.222 | 14.60 | 0.99 |
| COD | 0.978 | 0.054 | 4.38 | 0.24 |
| SHORTFIN MAKO | 0.324 | 0.000 | 1.45 | 0.00 |
| THRESHER SHARK | 0.136 | 0.000 | 0.61 | 0.00 |
| MONKFISH | 0.016 | 0.000 | 0.07 | 0.00 |
| REDFISH | 0.011 | 0.000 | 0.05 | 0.00 |
| CUSK | 0.011 | 0.000 | 0.05 | 0.00 |
| HADDOCK | 0.009 | 0.000 | 0.04 | 0.00 |
| BASKING SHARK | 0.000 | 3.182 | 0.00 | 14.24 |
| SPINY DOGFISH | 0.000 | 0.168 | 0.00 | 0.75 |
| SHAD AMERICAN | 0.000 | 0.085 | 0.00 | 0.38 |
| BLUE SHARK | 0.000 | 0.034 | 0.00 | 0.15 |
| HERMIT CRABS | 0.000 | 0.011 | 0.00 | 0.05 |
| THORNY SKATE | 0.000 | 0.007 | 0.00 | 0.03 |
| AMERICAN LOBSTER | 0.000 | 0.005 | 0.00 | 0.02 |
| SILVER HAKE | 0.000 | 0.001 | 0.00 | 0.00 |
| HERRING | 0.000 | 0.001 | 0.00 | 0.00 |
| TOTAL | $\mathbf{1 8 . 4 1 7}$ | $\mathbf{3 . 9 3 5}$ | $\mathbf{8 2 . 4 0}$ | $\mathbf{1 7 . 6 0}$ |
|  |  |  |  |  |

Table 23. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 4X from redfish-directed mobile gear trips.

| Species | Total Kept <br> (t) | Total Discarded <br> (t) | \% Kept | \% Discarded |
| :---: | :---: | :---: | :---: | :---: |
| REDFISH | 280.024 | 0.045 | 58.42 | 0.01 |
| POLLOCK | 106.457 | 0.000 | 22.21 | 0.00 |
| HADDOCK | 14.075 | 0.000 | 2.94 | 0.00 |
| WHITE HAKE | 4.672 | 0.000 | 0.97 | 0.00 |
| COD(ATLANTIC) | 5.870 | 0.000 | 1.22 | 0.00 |
| MONKFISH | 0.484 | 0.000 | 0.10 | 0.00 |
| CUSK | 0.538 | 0.000 | 0.11 | 0.00 |
| WITCH FLOUNDER | 1.021 | 0.000 | 0.21 | 0.00 |
| BARNDOOR SKATE | 0.119 | 0.488 | 0.02 | 0.10 |
| BLACK BELLY ROSEFISH | 0.551 | 0.003 | 0.11 | 0.00 |
| STRIPED ATLANTIC WOLFFISH | 0.111 | 0.009 | 0.02 | 0.00 |
| SMOOTH SKATE | 0.040 | 0.032 | 0.01 | 0.01 |
| AMERICAN LOBSTER | 0.031 | 2.257 | 0.01 | 0.47 |
| RED HAKE | 0.176 | 0.000 | 0.04 | 0.00 |
| HALIBUT | 0.231 | 0.128 | 0.05 | 0.03 |
| SILVER HAKE | 0.728 | 0.042 | 0.15 | 0.01 |
| WINTER SKATE | 0.019 | 0.160 | 0.00 | 0.03 |
| AMERICAN PLAICE | 0.098 | 0.000 | 0.02 | 0.00 |
| THORNY SKATE | 0.008 | 0.261 | 0.00 | 0.05 |
| WINTER FLOUNDER | 0.024 | 0.000 | 0.01 | 0.00 |
| SUMMER FLOUNDER | 0.002 | 0.000 | 0.00 | 0.00 |
| MACKEREL | 0.001 | 0.091 | 0.00 | 0.02 |
| TURBOT | 0.001 | 0.000 | 0.00 | 0.00 |
| UNIDENTIFIED GRENADIERS | 0.001 | 0.000 | 0.00 | 0.00 |
| SPINY DOGFISH | 0.000 | 57.595 | 0.00 | 12.02 |
| STONES AND ROCKS | 0.000 | 0.712 | 0.00 | 0.15 |
| BLACK DOGFISH | 0.000 | 0.455 | 0.00 | 0.09 |
| SHAD AMERICAN | 0.000 | 0.573 | 0.00 | 0.12 |
| LARGE-EYED ARGENTINE | 0.000 | 0.058 | 0.00 | 0.01 |
| SCULPINS | 0.000 | 0.026 | 0.00 | 0.01 |
| WHITE SKATE | 0.000 | 0.017 | 0.00 | 0.00 |
| LUMPFISH | 0.010 | 0.027 | 0.00 | 0.01 |
| ALEWIFE | 0.000 | 0.551 | 0.00 | 0.11 |
| LITTLE SKATE | 0.000 | 0.083 | 0.00 | 0.02 |
| HERRING | 0.000 | 0.117 | 0.00 | 0.02 |
| UNIDENTIFIED ARGENTINES | 0.000 | 0.006 | 0.00 | 0.00 |
| SHORT-FIN SQUID | 0.000 | 0.005 | 0.00 | 0.00 |
| AMERICAN JOHN DORY | 0.000 | 0.003 | 0.00 | 0.00 |
| SEA RAVEN | 0.027 | 0.014 | 0.01 | 0.00 |
| SPONGES | 0.000 | 0.030 | 0.00 | 0.01 |
| UNIDENTIFIED SCULPIN | 0.000 | 0.001 | 0.00 | 0.00 |
| NORTHERN STONE CRAB | 0.000 | 0.001 | 0.00 | 0.00 |
| JELLYFISHES | 0.000 | 0.005 | 0.00 | 0.00 |
| ATLANTIC ROCK CRAB | 0.000 | 0.001 | 0.00 | 0.00 |
| YELLOWTAIL FLOUNDER | 0.008 | 0.000 | 0.00 | 0.00 |
| UNIDENTIFIED SKATES | 0.000 | 0.136 | 0.00 | 0.03 |
| PORCUPINE CRAB | 0.000 | 0.001 | 0.00 | 0.00 |
| LONGHORN SCULPIN | 0.024 | 0.004 | 0.01 | 0.00 |
| EYED FLOUNDER | 0.011 | 0.000 | 0.00 | 0.00 |
| BUTTERFISH | 0.000 | 0.005 | 0.00 | 0.00 |
| ASTEROIDEA | 0.000 | 0.002 | 0.00 | 0.00 |
| ATLANTIC ARGENTINE | 0.005 | 0.002 | 0.00 | 0.00 |
| TOTAL | 415.367 | 63.946 | 86.66 | 13.34 |

Table 24. Observed predation on pollock based on stomach content data of various fish species collected from DFO RV surveys.

|  | Instances of <br> Pollock <br> Consumed | Number of <br> Stomachs <br> Examined |  |
| :--- | :--- | :--- | :--- |
| Predator | 19 | 30778 | Proportion |
| Atlantic cod | 1 | 36599 | $<0.001$ |
| Haddock | 12 | 3926 | $<0.001$ |
| White hake | 1 | 647 | 0.003 |
| Red hake | 5 | 6477 | 0.001 |
| Silver hake | 7 | 4519 | $<0.001$ |
| Pollock | 1 | 1222 | 0.002 |
| Atlantic halibut | 165 | $<0.001$ |  |
| Greenland halibut | 1 | 715 | $<0.001$ |
| Winter skate | 1 | 1243 | 0.001 |
| Spiny dogfish | 1 | 2025 | $<0.001$ |
| Longhorn sculpin | 2 | 750 | $<0.001$ |
| Sea raven | 3 | 664 | 0.004 |
| Monkfish | 2 |  | 0.003 |



Fig. 1. DFO Statistical Unit Areas for the Scotian Shelf, Bay of Fundy, and eastern Georges Bank. Areas forming the Western Component of pollock on the Scotian Shelf, Bay of Fundy, and Georges Bank are outlined as solid lines, and those comprising the Eastern Component are shown dashed lines.


Fig. 2. Landings of 4 VWX 5 pollock, shown with respect to the Total Allowable Catch (TAC). The striped bar in 2008 signifies incomplete landings. Prior to 1999, the quota year was Jan. 1 to Dec. 31. In 1999, the quota year was Jan. 1, 1999 to Mar. 31, 2000. Subsequently, it is Apr 1 to Mar. 31. All landings are shown for quota years. (2005-2007 TAC is for 4X only).


Fig. 3. Calendar year landings of pollock from the Eastern and Western components, 1970-2008. Landings for 2008 are from Jan. - Aug.


Fig. 4. Calendar year landings of pollock for the Western Component by statistical Unit Area, 1982-2008. Landings for 2008 are from Jan.-Aug.


Fig. 5. Spatial distribution of pollock mobile gear catches in 2007 (upper panel) and 2008 (lower panel) by 10 minute squares. Data for 2008 is from Jan-Dec. Dashed line separates Western and Eastern Components.


Fig. 6. Spatial distribution of pollock gillnet catches in 2007 (upper panel) and 2008 (lower panel) by 10 minute squares. Data for 2008 is from Jan.-Dec. Dashed line separates Western and Eastern components.


Fig. 7. Percentage of pollock landings by gear type for the Western Component, 1982-2008.




Fig. 8. Comparisons of 2008 port (dockside) and observer (at-sea) sample length measurements of pollock from the directed fishery, 2007 and 2008. Number of fish measured is shown for port (P) and observer ( O ) samples.



Fig. 9. Comparisons of 2008 port (dockside) and observer (at-sea) sample length measurements of pollock bycatch from the 4 Xpq redfish fishery (upper panel) and location of observed sets (lower panel). Number of fish measured is shown for port $(P)$ and observer $(O)$ samples.

## Between Ager Comparison

| DFO | Consensus Ages (NMFS/DFO) |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Primary Ager | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
| 0 | 2 |  |  |  |  |  |  |  |  | 2 |
| 1 |  | 6 | 1 |  |  |  |  |  |  | 7 |
| 2 |  |  | 9 |  |  |  |  |  |  | 9 |
| 3 |  |  |  | 10 |  |  |  |  |  | 10 |
| 4 |  |  |  |  | 9 |  |  |  |  | 9 |
| 5 |  |  |  |  |  | 8 | 3 |  |  | 11 |
| 6 |  |  |  |  |  | 1 | 8 |  |  | 9 |
| 7 |  |  |  |  |  |  |  | 7 |  | 7 |
| 8 |  |  |  |  |  |  |  |  | 2 | 2 |
| Total | 2 | 6 | 10 | 10 | 9 | 9 | 11 | 7 | 2 | 66 |

Agreement = 92\%

Within Ager Comparison

| DFO Primary Ager (1st Reading) |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2nd reading | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
| 2 | 4 |  |  |  |  |  |  |  |  | 4 |
| 3 |  | 30 | 1 |  |  |  |  |  |  | 31 |
| 4 |  |  | 16 | 2 |  |  |  |  |  | 18 |
| 5 |  |  | 1 | 18 | 1 |  |  |  |  | 20 |
| 6 |  |  |  |  | 14 | 2 |  |  |  | 16 |
| 7 |  |  |  |  | 1 | 8 | 1 |  |  | 10 |
| 8 |  |  |  |  |  |  | 7 |  |  | 7 |
| 9 |  |  |  |  |  |  | 1 | 3 |  | 4 |
| 10 |  |  |  |  |  |  |  | 1 | 2 | 3 |
| 11 |  |  |  |  |  |  |  |  | 1 | 1 |
| Total | 4 | 30 | 18 | 20 | 16 | 10 | 9 | 4 | 3 | 114 |

Agreement = 89\%
Fig. 10. Age frequency plots comparing pollock age interpretations by the primary ager for the $4 \mathrm{VWX}+5$ pollock stock. Top panel: Comparison of primary ager with NMFS/DFO ages from the 2001 Canada/US Ageing Workshop. Lower panel: Results of primary ager self-testing using pollock otolith sections from the 2007 fishery in 4 X .

20072008


Fig. 11. Percentage catch at size (upper panel) and age (lower panel) of pollock from large mesh otter trawl (cod end mesh $\geq 130 \mathrm{~mm}$ ), small mesh otter trawl (cod end mesh < 130 mm ), gillnet and handline/ longline from the 2007 and 2008 fisheries in the Western Component area (data for 2008 is from Jan.Aug.).


Fig. 12. Catch at age for pollock from the Western Component, 1982-2008. The area of the circle is proportional to the catch at that age and year. Two examples of recent strong cohorts are highlighted (data for 2008 is from Jan.-Aug.).


Fig. 13. Trends in fishery weights at age (kg) for pollock aged 3-7 from the Western Component, 19822008 (data for 2008 is from Jan.-Aug.).


Fig. 14. Standardized mobile gear (OTB 1-3) catch rate series (t/hr) for pollock for the Western Component, 1982-2008. Upper panel: CPUE by area; lower panel: area weighted CPUE for combined areas (data for 2008 is from Jan.-Aug.).


Fig. 15. Age-disaggregated catch rates for small mobile gear (TC 1-3) operating in the Western Component, 1982-2008. Two examples of recent strong cohorts are highlighted (data for 2008 is from Jan.-Aug.).


Fig. 16. Stratified mean catch per tow (kg) of pollock from the DFO summer RV survey in 4 X strata (stratas 474, 476, and 480-495) corresponding to the Western Component, 1970-2008. Data from 1984 to present is used in the VPA.

2007



Fig. 17. Pollock biomass distribution (kg/tow) from the 2007 and 2008 DFO summer survey. The solid line separates the Eastern and Western components.


Fig. 18. Stratified mean number per tow at age of pollock from the DFO summer RV survey in 4 X strata corresponding to the Western Component, 1984-2008.


Fig. 19. Weight at age for pollock ages 2-7 from the DFO summer RV survey in 4 X strata corresponding to the Western Component, 1982-2008.

2007


2008


Fig. 20. ITQ survey pollock biomass (kg/tow) distribution for 2007 and 2008 (solid circles), shown with respect to the average catch over the past 10 years (shaded rectangles).


Fig. 21. Trends in pollock biomass indices from the mobile gear CPUE series (1982-2008), DFO RV survey (1984-2008) and the ITQ survey (1996-2008) for the Western Component area.


Fig. 22. NMFS bottom trawl survey biomass distribution (kg/tow) for spring (upper panel) and fall (lower panel) surveys conducted in 2008 and 2007, respectively (solid circles) compared with the average for the previous 5 years (shaded rectangles). The solid line indicates the International Boundary.


Fig. 23. Comparison of biomass indices (kg/tow, scaled to mean of series) from the NMFS spring, NMFS fall and DFO RV surveys.


Fig. 24. Comparison of trends in age 2 recruitment, 4+ biomass, and age 6-9 fishing mortality for the Western Component from the Base VPA (CPUE: 1982-2004) and the Framework VPA (CPUE: 19822008).


RV Survey


Fig. 25. Age-specific residuals for the Base VPA formulation, Western Component pollock, for the relationships between In abundance index versus In population numbers for the CPUE series (upper panel) and the RV series (lower panel). Closed circles denote positive residuals and open circles denote negative residuals. (Bubble size is proportional to magnitude).


Fig. 26. Retrospective analysis of Western Component pollock from the Base VPA for age 6-9 fishing mortality (top panel), age 4+ biomass (middle panel), and age 2 recruits (lower panel).


Fig. 27. Base VPA 3+ population biomass compared to the $q$-adjusted survey total biomass for ages 3-8 for the Western Component.


Fig. 28. Trends in age 4+ biomass and age 2 recruitment of pollock in the Western Component from the Base VPA formulation.


Fig. 29 Age 4+ biomass and age 2 recruitment relationship from the Base VPA model for the Western Component. The beginning of year age 4+ biomass is shown for 2006-2008.


Fig. 30 Components of production (top panel) and production as indicated by the Base VPA compared with fishery yield (bottom panel) for the Western Stock Component.


Fig. 31. Trends in fishing mortality and landings of pollock for the Western Component from the Base VPA formulation.


Fig. 32. Partial recruitment values (3-year average) Western Component VPA results used in past assessments for projections and risk analyses.


Fig. 33. Risk of exceeding age 5+ exploitation or biomass rebuilding targets for Western Component from the Base VPA formulation.


Fig. 34. Risk of exceeding age $5+$ exploitation or biomass rebuilding targets for Western Component from the Base VPA formulation with assigned recruitment (3.4 million) at age 2 from 2006-2008.


Fig. 35. RV survey biomass indices from the Eastern and Western components, 1970-2008.


Fig. 36. Stratified mean number per tow at age of pollock from the DFO summer RV survey in strata corresponding to the Eastern Component, 1984-2008. The 2007 and 2008 survey values are shaded white and brown, respectively.


Fig. 37. Weight at age for pollock ages 2, 4, and 6, from the DFO summer research vessel survey in strata corresponding to the Western and Eastern components, 1982-2008.


Fig. 38. Smoothed (running average of 3 year) estimates of total mortality from RV surveys, Eastern Component pollock. Annual estimates of total mortality (unsmoothed) are shown as open circles.


Fig. 39. Pollock catch at size frequencies from directed fisheries in the Eastern Component (4W) in the 1980s and 1990s, compared to test fisheries in 2007/2008.


Fig. 40. Age composition of pollock catch by percentage from directed fisheries in the Eastern Component (4W) in the 1980s and 1990s, compared to test fisheries in 2007/2008. The 2007 and 2008 CAA values are shaded white and brown, respectively.


Fig. 41. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in $4 X$ from pollock-directed mobile gear trips. Top panel: observed set locations; bottom panel: percentage of catch kept and discarded by species.


Fig. 42. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 5Zc from pollock-directed mobile gear trips. Top panel: observed set locations, northeast Georges Bank; bottom panel: percentage of catch kept and discarded by species.


Fig. 43. Kept versus discarded bycatch reported for 2006-2008 combined observed trips in 4W from pollock-directed mobile gear trips. Top panel: observed set locations, 4 Wkl ; bottom panel: percentage of catch kept and discarded by species.


Fig. 44. Kept versus discarded bycatch reported for 2008 in $4 X$ from pollock-directed observed gillnet trips. Top panel: observed set locations, 4Xq; bottom panel: percentage of catch kept and discarded by species.


Fig. 45. Kept versus discarded bycatch reported for 2006-2006 combined observed trips in 4X from redfish-directed mobile gear trips. Top panel: observed set locations, 4Xpq and 4 Xmn ; bottom panel: percentage of catch kept and discarded by species.
1950-60 4X Summer


2003 4X Summer


| $\square$ Amphipod | $\square$ Copepod | $\square$ Crustaceans |
| :--- | :--- | :--- |
| $\square$ Digested Remains | $\square$ Fish | $\square$ Jellyfish |
| $\square$ Krill | $\square$ Shrimps | $\square$ Squid |

Fig. 46. Change in pollock diet (\% of prey weight) by fish size ( $\mathrm{cm}, \mathrm{FL}$ ) during summer in 4 X through the 1960s (upper panel), 1996 (middle panel), and 2003 (lower panel), based on stomachs collected from DFO RV surveys.
1950-60 4X Spring

1950-60 4X Autumn


| $\square$ Amphipod | $\square$ Copepod | $\square$ Crustaceans |
| :--- | :--- | :--- |
| $\square$ Digested Remains | $\square$ Fish | $\square$ Jellyfish |
| $\square$ Krill | $\square$ Shrimps | $\square$ Squid |

Fig. 47. Seasonal changes in diet of pollock (\% of prey weight) by fish size (cm, FL) based on stomachs collected during the 1960s in 4X from DFO RV surveys (upper panel: spring; middle panel: summer; lower panel: autumn).
1950-60 4VW Winter


1950-60 4VW Summer


| $\square$ Amphipod | $\square$ Copepod | $\square$ Crustaceans |
| :--- | :--- | :--- |
| $\square$ Digested Remains | $\square$ Fish | $\square$ Jellyfish |
| $\square$ Krill | $\square$ Shrimps | $\square$ Squid |

Fig. 48. Seasonal changes in diet of pollock (\% of prey weight) by fish size (cm, FL) based on stomachs collected during the 1960s in 4VW from DFO RV surveys (upper panel: spring; middle panel: summer; lower panel: autumn).

Pre 70's 4X Summer


Fig. 49. Temporal stability of fish prey in pollock diet (\% by weight) by fish size (cm, FL) based on stomachs collected from DFO RV surveys in 4X during the pre 1970s (upper panel), 1996 (middle panel), and 2003 (lower panel).


Figure 50. Diel feeding patterns (stomach fullness) for pollock collected during RV surveys during: A) pre 1970s summer, B) pre 1970s spring, C) pre 1970s winter, D) pre 1970s autumn, and E) 1995-2008 summer.


Fig. 51. Changes in the predicted weight (g) of pollock at 60 cm fork length based on length-weight relationships from DFO summer RV survey data, 1970-2008.

