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Proceedings of the Pollock Framework Assessment

1 May 2003; 16-18 June 2003; and 6-8 April 2004

Compte rendu des examens du cadre d'évaluation de la goberge

Le 1er mai 2003, du 16 au 18 juin 2003 et du 6 au 8 avril 2004

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Foreword

The purpose of these proceedings is to archive the activities and discussions of the meeting, including research recommendations, uncertainties, and to provide a place to formally archive official minority opinions. As such, interpretations and opinions presented in this report may be factually incorrect or mis-leading, but are included to record as faithfully as possible what transpired at the meeting. No statements are to be taken as reflecting the consensus of the meeting unless they are clearly identified as such. Moreover, additional information and further review may result in a change of decision where tentative agreement had been reached.

Avant-propos

Le présent compte rendu fait état des activités et des discussions qui ont eu lieu à la réunion, notamment en ce qui concerne les recommandations de recherche et les incertitudes; il sert aussi à consigner en bonne et due forme les opinions minoritaires officielles. Les interprétations et opinions qui y sont présentées peuvent être incorrectes sur le plan des faits ou trompeuses, mais elles sont intégrées au document pour que celui-ci reflète le plus fidèlement possible ce qui s'est dit à la réunion. Aucune déclaration ne doit être considérée comme une expression du consensus des participants, sauf s'il est clairement indiqué qu'elle l'est effectivement. En outre, des renseignements supplémentaires et un plus ample examen peuvent avoir pour effet de modifier une décision qui avait fait l'objet d'un accord préliminaire.

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ABSTRACT

In 2003 and 2004, the Maritimes Region of the Department of Fisheries and Oceans conducted an in-depth stock assessment of pollock (*Pollachius virens*). Such periodic evaluations, referred to here as Framework Assessments, are meant to be a comprehensive review of the biology, stock structure, the fishery, abundance indices, current assessment methodlology and approaches for determining acceptable harvest levels. This document contains the Proceedings from the three review meetings conducted during the Framework Assessment.

RÉSUMÉ

En 2003 et 2004, la Région des Maritimes du ministère des Pêches et des Océans a procédé à une évaluation approfondie de la goberge (*Pollachius virens*). Les évaluations périodiques du genre, appelées examens du cadre d'évaluation, permettent une appréciation exhaustive de la biologie et de la structure du stock, de la pêche, des indices d'abondance, des méthodes d'évaluation courantes et des approches utilisées pour déterminer les niveaux de capture acceptables. Le présent document rend compte des trois réunions tenues pour l'examen du cadre d'évaluation.

INTRODUCTION

The last in-depth assessment of pollock (*Pollachius virens*) occurred in 1999 (Neilson et al. 1999). Due to their schooling, semi-pelagic habits, pollock present special problems for stock assessment. For example, there have been concerns that the index of abundance, commercial fishery catch rates, may not be reliable. There have also been indications that the current management unit is sub-optimal. Since the last in-depth assessment, however, there has been considerable progress in the evaluation of stock structure, age determination, biology, and alternative indices of abundance, including hydroacoustics.

The Maritimes RAP has adopted an approach that separates the review of the assessment framework from the application of the framework to data as part of the annual fisheries management planning cycle. The topics to be considered in a framework review range from the definition of the management unit, through to the processes governing the productivity of the resource. Given the difficulties observed in the past pollock assessments and the availability of new information, the 4VWX5Zc pollock resource was chosen for a focused review of the assessment framework in 2003/04.

More specifically, the intent of the Framework Assessment is to produce an evaluation framework that will allow output and advice that is of relevance to the strategies of “Conserving Diversity” and “Conserving Productivity”, as described in the DFO Groundfish Objectives Based Fisheries Management Plan (OBFM).

The pollock assessment framework was evaluated in a phased approach, involving three peer-reviewed meetings in 2003/04, successively dealing with 1) biology, stock structure, other input data, 2) alternative indices of abundance, and 3) assessment approaches. The phased approach is seen to offer advantages in terms of providing:

1) opportunity to include advances in knowledge/approaches during the course of the year (not possible during a one week long meeting as was attempted for framework assessments in 2002),
2) opportunity to review work that often gets “short shrift” at typical assessment-focussed meetings,
3) improved potential to obtain external review from specialists, and
4) spreads the work load throughout the year.

PART #1 – MEETING OF 1 MAY 2003
BIOLOGY AND STOCK STRUCTURE

Conference Centre
St. Andrews Biological Station
St. Andrews, New Brunswick

The first meeting of the Framework Assessment focused on stock structure and the biology of pollock.

The agenda for the meeting appears in Appendix 1. The participants in the meeting are shown in Appendix 5.

Presentation: Incorporating Ecosystem Considerations into Fisheries Management

(Presenter - R. O'Boyle)

Summary

The review of the assessment framework for Scotian Shelf pollock affords an opportunity to expand the scope of the annual assessment to consideration of the impacts of the fishery on the other components of the ecosystem. Various initiatives are underway both regionally and nationally that explore how this expanded view might be formulated and implemented at an ocean industry sector level, but within the context of achievement broad ecosystem level objectives defined for a given ocean area. These initiatives are considering not only the objectives that would drive management but also the means as to how assessment against these objectives might be assessed.

A DFO national workshop was convened in Sidney, BC (February 2001) to identify the ecosystem-level objectives. A hierarchical structure was proposed (and adopted nationally), which consists of conceptual (high level) objectives or policy statements that govern the activities of all ocean sectors. Operational objectives based upon these would be developed and included in sector specific plans to control human impacts on the ecosystem. The highest level conceptual objectives were derived from the sustainable development literature and address both the conservation of species and habitat (environmental dimension) and sustainability of human use of the ecosystem (socio-economic dimension). The former was further broken down into sub-objectives to conserve the components of the ecosystem (biodiversity), the components role in the ecosystem (productivity) and the physical and chemical properties of the ecosystem (habitat). Each of these was further broken into sub-sub objectives, with that relating to biodiversity considering its maintenance at the community, species and population level, that relating to productivity considering the maintenance of the base of the food chain, trophic relationships and individual populations, and that relating to habitat considering the conservation of bottom features, water column properties, water and biota quality.

The Sidney workshop defined operational objectives as consisting of a verb, indicator and reference point, which would be developed from the conceptual objective through a process termed 'unpacking'. During this process, conceptual objectives would be stated in increasing detail until the point is reached when a measurable quantity can be identified. At this point, the operational objective would be defined that would be included in sector plans.

Three pilot unpacking exercises have been carried out in Maritimes; one in support of the groundfish OBFM plan (February 2002), one on aquaculture (June 2002) and one on oil and gas impacts (August 2002). The results of the groundfish exercise were presented, along with the lessons learned on how to improve the unpacking process. Details are provided in CSAS Proceedings 2003/004.

The presentation ended with initial thoughts on ecosystem assessment frameworks. It was noted that the assessment of efforts to conserve ecosystems necessitates consideration of a wide set of features relating to biodiversity, productivity and habitat, with many indicators and reference points possible, some qualitative as well as quantitative, in an environment of limited understanding of processes and relationships. A different approach appears to be needed for assessment, decision-making and communication. The Sidney workshop considered two approaches - the Traffic Light Method being explored in Maritimes Region and the Index of Biotic Integrity being used in freshwater systems. The former has the advantage of allowing inclusion of many features of the ecosystem and its management into one framework but while promising, a number of issues remain unresolved.

The presentation highlighted some of the progress being made and challenges being met in considering the inclusion of ecosystem-level objectives into sector plans, such as that for fisheries. During the pollock assessment framework review, it will be important to keep the broader ecosystem-level effects in view and where possible include indicators and reference points of these effects into the framework.

Discussion (Rapporteur R.K. Smedbol)

This presentation is relevant to the pollock framework meeting in 3 major ways:
1. Development of productivity reference points.
2. Determination of the position of pollock within the food web.
3. Enhance discussion of maintenance of populations and population structure
    - The point of presenting OBFM is to broaden the discussion into areas other than just productivity.

The structure and components of OBFM have been approved in principle. The debate concerning OBFM occurs at the level of implementation (operational level); e.g. within management plans for species. Current management plans for groundfish are moving in the direction of implementing OBFM. However, not all of the components of OBFM have been addressed. For instance, the effects or harvest methods on habitat quality are rarely addressed. An example of analyses relevant to the implementation of OBFM was the report on ‘Fisheries management planning for

the Canadian Eastern Georges Bank Groundfish Fishery (DFO Maritimes Regional Fisheries Status Report 2002/01) which included analyses of benthic disturbance (area trawled on Georges Bank) and incidental mortality.

Table 10 from the current groundfish management plan was tabled at this meeting for consideration.

The question was raised as to whether the "unpacking" process for a particular objective (i.e. target species) include operational items for related issues. For example, would the process consider issues concerning a forage species upon which pollock feed? The author responded that such issues can be addressed, but only those that pertain to human activities; such as exploitation of a species preyed upon by the species in question.

The point was raised that incidental catches of the species in question in other fisheries should be considered in the process. Gaps in reporting within other fisheries are known to exist (e.g. finfish catches in invertebrate fisheries).

Action Item: Authors should investigate pollock catches in other fisheries (including mackerel traps) for the next Assessment Framework meeting.

Action Item: Authors should note the species spectrum in herring weirs for the next Assessment Framework meeting.

Presentation: Overview of Pollock Biology
(Presenter - J. Neilson)

Summary

As background for those that were not familiar with the biology of pollock, John Neilson presented a brief summary of the key aspects of the biology of pollock, based on previously published and unpublished studies.

The range of pollock extends from off southern Labrador, and off southern Newfoundland, along the Scotian Shelf, Bay of Fundy and Gulf of Maine to about Cape Hatteras, North Carolina. Areas of highest abundance include the Scotian Shelf and Grand Banks.

Considering the early life history, Information is available from several multi-year studies on the Scotian Shelf and Bay of Fundy. Pollock eggs are buoyant, and four egg stages are recognized. Unlike cod and haddock, pollock eggs can be identified at stage 1. Thus, there is a better chance to relate early stage egg distributions to the location of spawning. The time from the start of Stage 1 to hatch is about 7 days at 7 degrees The ichthyoplankton survey data suggest two groupings: 1) off southwest Nova and Georges Bank, and 2) central Scotian Shelf. The maximum number of occurrences of sets with pollock eggs was found in January to December in the

Scotian Shelf Ichthyoplankton Program. Egg release occurs earlier than is the case for haddock, and unlike cod, there is only one peak in spawning activity.

Also in contrast to many other gadids, the juvenile stage of pollock is thought to occur in coastal waters. This coastal stage seems to be obligate, with no juveniles found offshore in midwater trawl surveys conducted in the 1980s. The duration of the stage where fish are associated with the coastal environment appears to be about two years.

Considering the movement and migrations of pollock, the coastal nature of the distribution of juveniles makes them amenable for capture and tagging. Extensive tagging work has been done throughout the management unit, but has only recently been summarized. Older adults do not appear to survive capture in bottom trawls well, and marking of such fish appears problematic. John Neilson presented a series of slides that indicated that recaptures of marked juveniles indicate that such fish do not mix completely throughout the management unit.

The length and age of pollock at maturity has followed a declining trend recently, similar to other groundfish stocks. USA studies published in 1993 indicate that L50 were 41.8 and 39.1 cm for males and females, respectively. This contrasts with a study for the Bay of Fundy published in the 1960s, that indicated that females attained maturity at 62.5 cm and males at 58 cm.

Pollock ages are determined from otoliths, and have been compared with “true ages” obtained from mark-recapture work, where small released fish whose age can be inferred from length frequency analyses are later recaptured and returned with otoliths. Growth rates differ within the management unit.

The current age reader notes different patterns of otolith growth and appearance within the management unit. Some preliminary results were presented that indicated that pollock from the Western Scotian Shelf tend to be typified by a large central area, and appear quite “contrasty”. The eastern type appears less contrasty, and has smaller centres. The age reader notes areas where both types found (4Xn).

The characteristics of the fishery was discussed next and it was noted that the large mobile gear fishery was focussed on the fall and winter months. Other gear sectors tend to be operate more on a year-round basis, but with a peak in activity during summer months.

Year-round hydroacoustic observations collected onboard the fishing vessel *Cape John* was presented next. It was noted that the highest biomass density was recorded in December to January, consistent with the commercial fishery catch rate information. The pollock aggregations were also shown to extend up to 30 m off bottom. For comparison, the survey net vertical opening is about 4 m.

Considering the nature of adult aggregations, pollock are known to aggregate by size/age. Pollock sometimes form very dense aggregations. From hydroacoustic investigations, it was found that these aggregations can form during night and

disperse during the day. Physical bathymetric features such as “sea-mounds” seem to be a focus for pollock schools. Schools can persist in the same area for a considerable period.

Pollock are thought to have relatively few enemies apart from man. Some cannibalism has been noted. Harbour seals occasionally eat adult pollock. Pollock and silver hake eat similar food and thus are competitors. A comprehensive review of the available diet information has been prepared for this meeting.

Discussion (Rapporteur - R.K. Smedbol)

Pollock may be taken by grey seals in addition to harbour seals. Grey seals may not ingest the heads of adult pollock, therefore if pollock tissue was present in a seal gut, it is unlikely that this tissue was recorded as pollock. It was more likely to be recorded as “unidentified gadid”. It was suggested that grey seals are likely to consume more pollock than harbour seals.

Questions raised for future discussion of stock structure:

- How do eggs and larvae get to the inshore from the offshore?
- Why are juvenile stages found inshore? - refugia, habitat, feeding?
- Have there been long-term changes in the inshore habitat?

Pollock are basically a schooling species; the onset of schooling behaviour begins during the juvenile (inshore) stage.

The assertion that 0-group pollock are not found in offshore habitats was challenged, with a participant noting that offshore fishing gear is not designed to capture small pollock. Why is the absence of catches offshore considered sufficient evidence for the absence of juvenile pollock offshore. In response, it was noted that during RV surveys, the gear catches small cod and haddock, but not pollock. During further discussion, it was noted that differences in vertical/depth distribution or behaviour could also account for the absence of 0-group pollock in RV surveys. It was agreed that while we cannot be conclusive about the distribution of 0-group pollock, the available data do suggest that the coastal environment is a critical component of the early life history of pollock. Possible avenues for follow-up included use of different trawls more suited for the collection of smaller fish.

Presentation: Decadal Shifts in the Diet and Growth of Pollock on the Scotian Shelf: Responses to a Dynamic Ecosystem

(Presenter E. Carruthers)

Summary

Pollock (*Pollachius virens*) on the Scotian Shelf have shown marked differences in diet between the period 1958-1967 and a more recent period when stomach samples were available (1996-2002). While euphausiids appeared to dominate the diet of pollock during the earlier period in terms of percentage by weight, particularly in

smaller fish, the diet of pollock during the more recent period had a larger contribution from decapods (*Pandalus* sp.) and fish prey. Among fish prey, sand lance (*Ammodytes* sp.) accounted for the largest fraction of prey weight during the early period, but silver hake (*Merluccius bilinearis*) and herring (*Clupea harengus*) dominated the more recent stomach samples. A higher proportion of empty stomachs was also observed during the later period. Changes in the diet of pollock appeared to reflect the abundance of significant prey on the Scotian Shelf. Concurrent with the reduced prevalence of euphausiids in the diet of pollock, continuous plankton recorder data indicated that the abundance of euphausiids declined about two orders of magnitude from the early 1960s to the late 1990s. Such changes in the feeding opportunities for pollock were concurrent with lower rates of growth during the 1990s, as indicated by examination of otoliths taken during research vessel surveys.

Discussion (Rapporteur S. Gavaris)

The principal thesis of the working paper was that marked changes in the stomach content of pollock between the 1958-1967 period and the 1996-2002 period reflected differences in the abundance of prey. Much of the discussion concerned the adequacy of control for other factors that might affect stomach contents. Factors that were noted included depth, size composition, maturity, area of capture and season of capture. There were concerns that differences in any of these factors between the two time periods, rather than prey abundance, may have resulted in the changes observed in stomach contents. Many of these factors were investigated, but individually. Because this is not a controlled experiment with a complete block design, such marginal averages may not be easily interpretable. Further, the significance of the effects should be established in relation to the natural variation in the data. An analysis of variance treatment or similar multivariate procedure seems warranted, if the data are sufficient.

Prey abundance was derived from observed trends from bottom trawl surveys. Bottom trawl surveys do not always provide reliable indices of abundance. Indeed they have not given reliable results even for pollock, a species susceptible to bottom trawl fishing. Assessments may include bottom trawl survey results but they often incorporate a broader suite of information. It was suggested that trends from assessments should at least be considered, where these are available. This was particularly noted for silver hake where the bottom trawl survey trends do not correspond with the assessment results. It was also noted that fishing for silver hake in Emerald and LaHave Basins ceased during 1979 to 1997 and this likely affected the local availability.

A supplementary thesis of the paper was that growth of pollock was influenced by the changed availability of prey, particularly euphasids. An association was drawn between the lower euphausiid density and lower size at age in the 1990s. Again concern was expressed about the influence of other factors that affect growth, including area of capture, temperature and year class strength (e.g. effect of the strong 1979 year-class).

Certainly the differences in growth between the east and west regions of the Scotian Shelf should be accounted for given the divergent trends in pollock abundance. It was suggested that low food availability may have a greater impact on plumpness rather than size at age and changes in condition factor should be investigated. It was also noted that some analysis of the energy balance between predation on krill and fish may support the case that feeding on krill results in greater net gains. It was speculated that euphausiid outbursts rather than the average trend in euphausiid abundance may be more important for pollock growth. A substantial portion of the pollock catch is taken on Georges Bank. Recent overviews of the Georges Bank ecosystem have indicated that primary production does not show much variation over the past 100 years and that the abundance of *Calanus* sp, an important prey item on Georges Bank, has not displayed much variability. It was asserted that this does not appear consistent with the change in growth. However, the authors' data did not support the assertion that *Calanus* sp. is an important prey item for the sizes of pollock included in the present study.

Changes in the productivity regime are an important consideration for establishing harvest reference points. The results of this working paper suggest that ecosystem changes may have altered the productivity of pollock. It is recommended that the refinements in analysis should be pursued in order to confirm if these indications can be supported.

Presentation: Stock Structure of Pollock in NAFO Divs. 4VWX5Zc
(Presenter – J. Neilson)

Summary

The stock structure of pollock (*Pollachius virens*) in Northwest Atlantic was examined using information from a variety of sources including the commercial fishery, research vessel surveys of various stages of the life history, population parameters, meristic and morphometric data and mark-recapture information. It was concluded that there was sufficient information to suggest the design of management measures to account for an eastern (4VW) and a western (4X5Zc) components. The current eastern and northern boundaries with NAFO Divs. 4T and 3Ps appear appropriate and should be retained. The boundaries of the stock to the south in SA 5 appear less clear, however. The suggestion that the International Boundary form the limit of the management unit is based more on operational considerations rather than considerations of stock

Discussion (Rapporteur: L. Van Eeckhaute)

The conceptual model of pollock biology is as follows: spawning occurs during a 3 month period in the winter (Dec., Jan., Feb.), juveniles move inshore until they reach about 30 cm in length and adults aggregate offshore to spawn.

Growth Rates:

There is a difference in growth rates of pollock for eastern and western areas suggesting that groups of fish stay in an area once they are adult so they could be managed on that basis. Although there was an environmental issue in the east which did not occur in the west, the pattern of mean age at length for pollock by unit areas was the same in the late 1970's as was shown for the 1995 to 2002 period and separate keys have been used for east and west over the entire time period. This difference in productivity indicates a need to use different harvest rates for the eastern and western components.

Tagging Evidence:

A clarification of how expected recaptures was calculated was requested. Pollock directed effort should be taken into account. Before 1993 in the National Sea offshore fleet, specific boat captains directed for pollock especially in 4VSc while others directed for a mixed species fishery. The calculation uses groundfish effort but some boats direct specifically for pollock. The authors later explained that species directed for was included as a factor in their model of mobile gear fishing effort. The 30 day exclusion period may not be long enough. The expected recapture rate, which is based on unit areas, may be too fine a scale as the management unit consists of several unit areas. It was suggest that results should be shown by cohort as fish were tagged as age 0 or age 1. The authors should look at tag recoveries of spawning fish since it appears that adults mix after spawning.

The relevance of tagging juveniles rather than spawners was questioned. Tagging of juveniles gives no data about mixing of adults. Egg/larval distribution may be a better indicator of spawning concentrations. It would have been more useful to tag spawners but since trawling was not an effective method of capturing fish for tagging as they did not survive, the tagging effort was turned to tagging of juveniles from traps near shore. Juveniles may go back to their spawning site to spawn themselves and then mix as adults subsequently.

Most recaptures were from very near the release site and there appeared to be more potential movement from 4W to 4X than the other way around. It was noted that there was an imbalance between numbers tagged in the east versus the west.

It generally has been recognized that there are separate spawning components but lots of mixing after spawning. We need to consider that we are managing a fishery and the most important consideration for this is the mark/recapture data.

Conservation of Spawning Components:

One of the objectives is to make sure that exploitation does not concentrate on one spawning group as conservation of populations is one of the objectives. Exclusion zones at certain times of the year could be used to protect spawning components but at other times of years when groups mix this could be handled differently. Rebuilding of components is also an objective so spawning units must be rebuilt. Components

can be protected based on the egg/larval distributions. The need to conserve individual stock components is also supported by the evidence that some spawning units are less productive than others (growth differences). The problem is similar to that for 4X cod where the management units are too large to protect discrete spawning units. Functional conservation measures are needed to manage the middle zone where there is overlap. This pertains to other species as well.

Egg/larval Distribution:

Nothing was seen in the egg distribution plots that correspond with the eastern most fishery. This could be due to lack of coverage, e.g. no coverage in eastern areas by SSIP during time when eggs/larvae are present due to ice cover.

Water circulation patterns on Georges Bank and Browns would tend to entrain larvae.

Patterns in Fishery:

Juvenile distribution is thought to be contiguous along the coast but there were reports from industry participants at the meeting that there are different sizes of juveniles, for example, Port Mouton has bigger juveniles than Pubnico. Large otter trawlers focus on winter spawning concentrations and then pollock spread out over the Scotian Shelf. Table 2 shows where discontinuity in landings occurs, but this changes over time. There was a concern with the accuracy of fishery locations. The observer data does show fishery locations accurately. Fishery info is compromised by the haddock box which came into affect in 1986. Fishery information should have a lower weighting than egg/larval and tagging data. It may be useful to overlay egg/larval info with spawning time fishery information.

Anecdotal information from the fishery supports homing of pollock. For example, it is felt that pollock do home to Browns Bank as evidenced by their occurrence there every Dec. 5 at 68-72 fathoms. These fish would be gone by mid-Feb. Fishermen feel that Georges Bank/4X is a unit.

Movement of pollock appears to be influenced by prey species. Fishermen note that pollock from the western portion off Yarmouth would be eating gaspereau in April and May. The summer run is following herring.

There is a consistent winter fishery in 4V year round which would suggest a spawning unit in 4V.

Genetics:

DNA analysis has been used to differentiate between redfish stocks. A **recommendation** was made for some future genetics work for pollock but an appropriate hypothesis that can test for genetic distinction is needed. However, with or without genetic differences, productivity patterns could preclude considering them separately.

A representative from DFO Fisheries Management asked that if there is a concern over the potential depletion of a component, could results for separate components be presented? The response indicated that the process is such that results from the framework process would not be in effect until the fall of 2004. The representative from DFO Fisheries Management indicated that this would not be a problem, but if management measures are to be targeted towards eastern and western components, then the framework process needs to deal with both parts.

Conclusions Regarding Stock Structure:

Adult distribution at spawning time combined with egg and larvae information (proxies for spawning areas) and other available data (Neilson et al. 2003) suggest that the current management unit contains separate spawning components.. To meet the objective of protecting the diversity of the pollock resource, the following changes to the current assessment approach were **recommended**:

The meeting participants agreed there were sufficient grounds to suggest that future stock assessments explicitly deal with both the eastern and western pollock stock components on the Scotian Shelf. However, it was noted that the available data do not allow a precise resolution of the boundary. There was general consensus that on pragmatic grounds, the line defining the boundary between the eastern and western components should be the 4X/4W boundary for assessment purposes. It was noted, however, that unit areas 4Xm and 4Xn show affinity with the slower-growing eastern component, and calculation of the catch at age and indices should reflect this.

Growth in 5Z is comparable to that in 4Xpq. Growth rates are slower on Scotian Shelf than on Georges Bank. Spring survey distributions show the ICJ line as a useful boundary. Fishermen observe that pollock gillnetters follow fish north from NE peak and lose them in June at the ICJ line. Mixing over boundary line appears to be less of a concern on Georges Bank but based on available fisheries distribution information and mark recapture studies, is probably more of a concern across the 5Y boundary. Egg/larval surveys have insufficient coverage and information. More work is needed here to resolve this issue. There is some evidence to treat 4Xs separately but it may not be sufficient.

The boundary between 4X and 5Y is important because it is near the centre of the current fishery. Additional data are required to resolve the boundary of the stock unit in the Gulf of Maine area. It may be more appropriate to decide at the next two meetings of the framework assessment whether more stock structure work is required or if other research recommendations from the later meetings have higher priority.

PART #2 – MEETING OF 16-18 JUNE 2003
DESCRIPTION OF THE FISHERY AND ABUNDANCE INDICES

Conference Centre
St. Andrews Biological Station
St. Andrews, New Brunswick

This document is the record of the second meeting discussion the assessment framework for pollock, held June 16-18, 2003, at the St. Andrews Biological Station, St. Andrews, New Brunswick. The background, terms of reference and rationale are outlined in the minutes of the first meeting. This second meeting explored the quality of information and indices derived from fishery information and research surveys.

The agenda for the meeting appears in Appendix 2. The participants in the meeting are shown in Appendix 6.

Presentation: A Summary of Fishery Information for Pollock
(Presenter – D. Clark)

Summary

Pollock are distributed from the south coast of Newfoundland through the Gulf of Maine in 3Ps, 4VWX and Subarea 5. Pollock fishing has little or no impact on cusk or white hake, species which are closely monitored at present, and pollock directed effort has remained low in recent years. Pollock is caught as a secondary species in other groundfish-directed fisheries, but this has been accounted for in assessments of the resource. Bycatch in small mesh redfish trips will increase partial recruitment of 3 yr old pollock. Landings and distribution of the fishery have declined since the mid-1980's, but there have been recent improvements in the fishery in a limited geographic area relative to historical pollock distribution. The improved catch lies in the 4Xopqrs5 area defined as a potential management unit, but is restricted to the 4Xpq area. In interpreting the recent improvements in pollock recruitment and abundance, careful consideration of the geographic scope of this recovery is critical to ensure the magnitude of the resurgence is accurately determined. Furthermore, if separate spawning components inhabit those areas which are currently at low abundance, a general resurgence may not follow from the improvements in western 4X. An index of the geographic extent of the fishery relative to historic range, may be a useful gauge of productivity for this resource. Finally, the fishery now is focused in areas adjacent to the international boundary. It is likely that the same resource is exploited across the jurisdictional boundary, and further investigation of the degree of movement is warranted.

Discussion (Rapporteur – Heath Stone)

Many of the comments which followed this presentation were in relation to the selection of fleets, fisheries and gear types to be used in CPUE analyses. It was

pointed out that many of the ITQ mobile gear vessels < 65' do not have enough quota to direct for pollock and use their allocations to cover pollock bycatch when directing for other groundfish species. Trips which direct for silver hake should not be used in catch rate analyses because they use a "Nordmore Grate" to reduce pollock bycatch. There have also been attempts to reduce cod bycatch in the pollock gill net fishery by changing the way the net is hung (i.e. no. of meshes per ft). Therefore, the potential exists for many distortions in the data used for catch rate analyses because of small quotas, changes in gear configuration and bycatch restrictions on pollock, particularly in 4X (where many changes have occurred in recent years). The TVRP vessels <65' have more quota and can direct for pollock and therefore should be selected as prime candidates for use in catch rate analyses. In any case, scientists must be careful when selecting data for catch rate analyses, since there have been many changes in the commercial fishery, particularly in the offshore component.

Concern was expressed over the change in distribution of the pollock fishery, which has shifted from 4VW in the 1980s to 4X in recent years, where most of the fishery is now concentrated. This change occurs partly from management measures which have restricted the fishery in the east (i.e. closure of the cod fishery in 4VW) as well as to spatial changes in resource distribution. There are now large concentrations of pollock in the GOM area which are fished by both Canada and the USA. It was not clear if the spatial/temporal distributions patterns for pollock in the RV surveys reflect this trend as well. If the stock is now restricted to a smaller geographic area, use of commercial CPUE data to reflect stock abundance may be problematic, since it may not reflect the trends in abundance for the entire stock, but only a portion of the stock. It was noted that distributional changes have also occurred for cod and white hake, particularly in the SWNS area.

Presentation: Evaluation of Commercial Fishery Sampling Adequacy for Pollock in 4VWX5Zc

(Presenter – J. Neilson)

Summary

The pollock stock assessment depends heavily on adequate reconstruction of the catch at age. This is because commercial fishery catch rates are used as indices of abundance. These catch rates are disaggregated into age-specific indices through application of the appropriate gear-specific catch at age. Most recently, this has been the catch at age for the small (Tonnage Class 1-3) mobile gear fleet. The purpose of this working paper was to review the current sampling of this resource and indicate any deficiencies. In general, the authors concluded that the commercial sampling of the pollock fishery appears to be covering all spatial and gear components of the fishery well. Coverage has been less complete in the Bay of Fundy component.

Discussion (Rapporteur – H. Stone)

Contemporary sampling of pollock for length information is considerably improved. The CAA goes back to the early 1980s and sampling has been good since that time

with proportionately more age determinations than in the past. It was suggested that a summary table on how the CAA is constructed would be useful. (Note that gear/area length composition and age data is currently split between 4VW and 4X but not by unit area and data from observed trips (mainly redfish) and port samples are both used in CAA).

There are some limitations, however, in that sampling within the Bay of Fundy area is considered to be low. This lack of coverage in the Bay of Fundy may be an issue if growth rates differ from the adjacent 4Xpq area (which is well sampled for length information). There is a need to compare the available length frequency data from both areas for years in which adequate sampling occurs. Age information for the Bay of Fundy is available and appears to be accurate (based on comparisons with known age fish from tagging studies). It may be possible to construct a CAA for the Bay of Fundy which would be useful in catch rate analyses.

Presentation: Pollock (*Pollachius virens*) as Bycatch in 4VW/4X5 Groundfish Fisheries, 1997-2003

(Presenter – T. McIntyre)

Summary

The objective of this working paper was to investigate the catch composition in the 4VW and 4X5 groundfish fisheries. Data used includes domestic landings, commercial port samples, observer samples, and commercial log books. This report presented the bycatch of pollock separated by the two managements units, gear types, and main species sought/caught. The gear types included otter trawlers, longline, handline, gillnet, and others. The main species focused on were cod, haddock, redfish, and others. An attempt was made to further separate the otter trawl data according to mesh size, but there were not sufficient data available.

Following the separation of the bycatch data eight cases were identified for further attention: OTB cod 4X5; OTB haddock 4X5; OTB redfish 4X5 & 4VW; LL cod 4X5; LL haddock 4X5; GN cod 4X5; LHP cod 4X5. These eight cases comprise the majority of the pollock bycatch. The geographical distribution of the pollock bycatch in each of these eight cases was illustrated. The cod, haddock and redfish otter trawl fisheries in 4X5 and the cod gillnet fishery in 4X5 have higher percentages (using main species as percentage basis) of pollock as bycatch over time. The pollock bycatch in the cod and redfish fisheries appears to be increasing over the last 5 years.

The size composition was investigated comparing the difference in small fish (43 cm & 49 cm) in the eight cases and comparing the differences between small fish (43 cm) in the port sample *vs* observer data for each case. The geographical distribution of the port sample and observer sample data was also illustrated. Only Cod OTB, Haddock OTB, Redfish OTB, and Haddock LL for 1999-2003 in 4X5 were illustrated because of the lack of observer or port sample data for the other cases. These figures show similar spatial distribution of the port samples and observer samples for each case. The data appears to show a difference between the small fish

composition of the port sample data *vs* observer sample data in some cases. Catch at age was determined for each area, gear, main species combination for future yield type analysis.

Discussion (Rapporteur – H. Stone)

The authors investigated the catch composition of pollock in other groundfish fisheries using the criteria that the main species caught/sought is "the one with the highest catch for the trip". The point was made that up to four species (i.e. cod, haddock, pollock, white hake) could be the main species caught/sought at various times within a mobile gear trip. This occurs because fishermen may direct for different species at various times within a trip to maximize their economic returns depending on the market prices and the quota allocations they have for each of these species. Analyses based on individual set data (i.e. from log records) or day by day records (i.e. from ZIFF) may provide a better approach to determining the main species sought/caught within a trip.

The catch of pollock in the redfish fishery has always been about 5-10% of the total pollock landings due to the smaller mesh size used (90 mm) in the redfish fishery and the overlap in distribution of these two species. All pollock catches from this fishery are reported in the commercial landings data and are accounted for in the CAA (i.e. with separate LFs and ALKs). Of concern is the possible loss of production to the pollock fishery through growth overfishing since smaller/younger pollock would be captured to a greater extent in the redfish fishery. (An analysis similar to that of Sinclair and Waldron on the loss of production of silver hake to small mesh gear fisheries would be useful in this context). There may also be implications on partial recruitment to the pollock fishery.

Comparisons of the length composition from observed and non-observed pollock catches in the redfish fishery would be useful to indicate if discarding of small pollock is occurring. However, if this type of analysis does not show a difference, it is not conclusive evidence of no highgrading, since port samplers may not sample what they consider are "size biased" trips. To further investigate the potential for discarding of small pollock, it would be useful to look at individual set information from log record data. It was also pointed out that there may be geographic differences in the length compositions of pollock captured from cod directed and haddock directed mobile gear trips and that this may be worthy of further investigation.

Presentation: An Evaluation of Commercial Fishery Catch Rates as an Index of Abundance for Pollock in Divs. 4X5.
(Presenter – J. Neilson)

Summary

In the absence of reliable fishery-independent indices of abundance for pollock in 4VWX5Zc (Scotian Shelf, Bay of Fundy and the Canadian portion of Georges Bank), there has been considerable effort in past assessments devoted to describing trends in commercial fishery catch rates as indicators of abundance. Commercial catch rate

investigations are often subject to important qualifications and limitations. In the context of the periodic framework assessment of pollock, it is therefore important to carefully assess both the strengths and limitations of commercial fishery catches as indices of abundance.

The authors recommended that the mobile gear catch rates continue to be used as an index of abundance. The age specific indices provided indicated some consistency in the interpretation of year-class strength that appears to support the current use of commercial fishery catch rates in an age-disaggregated mode. The authors noted, however, that attempts to refine the index over past assessments has only resulted in modest gains in the explanatory power of the model, and there is considerable unaccounted variance in catch rates remaining.

Previous assessments have suggested that inclusion of interaction terms in the model could improve model fit. This document represents the first in-depth examination of the use of interactions models for the pollock assessment. They have provided insight into the robustness of the conclusions of the main effects models by allowing examination of discrete combinations of important factors such as area and season. Such detailed examination allows us to comment, for example, that the large interannual increase in the catch rates from 2001 to 2002 in the mobile gear main effects analysis seems supported by most of the specific predictions the authors examined, but the scale of the increase appears suspect. The interactions modeling approach presented some challenges, however. As indicated earlier, a more selective filter was necessary to reduce the number of vessels in the model from 175 to 48. Even then, the authors were unable to achieve model predictions in some years. Overall, the nature of interactions in the gillnet model may be sufficiently gradational for major fishery months (July-September), as opposed to contradictory, that main effects modeling may remain adequate to represent the catch rate time series.

The authors therefore considered that the gillnet catch rate series has some promise as indices of abundance. They recommended that the series be made available for possible inclusion in the development of the Assessment Framework for pollock.

Discussion (Rapporteur – D. Clark)

Considering mobile gear catch rates, the meeting participants made the following observations:

- Catch rates currently start in 1982, reflecting availability of catch at age, but could be pushed back farther without age disaggregation.
- Industry participants noted that pollock are chasing krill in summer in 4Xpq; this is when the summer high catch rates are found. This may reflect fish concentrating in an area of high prey availability.
- There have been gear manipulations, which increase the selectivity for small fish over about the last 4 years. This has been restricted through gear regulation in June of 2003. It will have affected catch rate for 3 yr. olds to the greatest extent.

- It was suggested that the selection of vessels in the catch rate analyses be refined. Possibly consider TVRP vessels on their own (this will generally include pollock directed fishing). Fishing patterns, in terms of fleet composition, are expected to remain stable, in the short term at least, so identifying a consistent set of vessels should allow for comparisons
- Catch rates of pollock during cod, haddock and redfish-directed trips were considered briefly during the meeting. Catch rates of pollock as bycatch are coarse measures, which would need to be refined before further consideration.
- Catch rates as bycatch in redfish will not be informative because the fishery started only in the mid-1990's.
- Currently, the data were aggregated to the subtrip level. Meeting participants asked if the aggregation of data to the trip level is useful? It may reduce the variability, but this should be investigated.
- 'Cape class' boats (TC5) could be included in catch rate analyses, as they fished on Georges Bank up to 2002. It was suggested that the authors look to see if the catch rate patterns are the same and potentially include more data and a longer series, as TC 5 vessels formed the primary fishery in the 1980's.
- Interaction terms should be considered in re-analyses and if they are significant, alternative analyses of catch rates in a fashion similar to a survey analysis could be attempted.
- Investigation of skewness in the catch rates should be attempted to determine if a small number of trips are driving the trends.
- Are catch rates a reflection of resource concentration? CPUE and RV weight/tow will be smoothed for comparison and presented as a ratio by year. This was looked at briefly at the meeting and indicated a divergence in the last 4 years, with the catch rates more optimistic than the RV survey.
- Interactions – Should we use F values rather than deviance to determine the significance of the interactions. The main effects have much higher F's, suggesting these are of overwhelming importance.
- Why is there a big change in catch rates between 4Xr and 4Xq? The fishing grounds are well separated, not really adjacent.
- Why are there very low catch rates in December? Is this an artifact of how the data are selected to reflect directed pollock fishing? This may need further exploration, and seems to be a different trend than is seen for larger vessels.
- It was noted that the FRCC will be asking if productivity and State of stock are low medium or high for pollock. They will not necessarily expect, or make direct use of, an exact numeric value for either.

Considering next gillnet catch rates, the following comments were made by participants:

- Mesh size in gillnets has shifted from about half of fishermen using 5 ½" mesh to low levels of 5 ½" mesh in the fishery since the early 1990's, but been consistent in recent years. Most fishermen are fishing 28-32 nets and licensed for 40 nets. A large percentage of fishermen is recording 40 nets regardless of what they deploy. This is to keep from being restricted to lower net counts in the future.

Given this concern over the use of number of nets as a measure of effort, It was determined that catch/day will be more useful as a measure of effort.
- There are three fleets of gillnet vessels that fish discrete areas. These could potentially be looked at separately in the catch rate standardization. Effort is not recorded for most Bay of Fundy vessels before 1996.
- Gillnet catch rates do not provide a recruitment index (age3) but do provide information on ages 4-8 (Vs. 3-7 for otter trawl).

Presentation: Evaluation of Research Vessel and ITQ Survey Data as Abundance Indices for Pollock

(Presenter – E. Carruthers)

Summary

Recent pollock (*Pollachius virens*) assessments in the Canadian Maritimes have been based on commercial fishery catch rates. Many researchers have argued for the inclusion of fishery independent data in stock assessments since these data would not be subject to changes in fishing patterns such as the redistribution of effort or technological advances resulting in changes in efficiency of fishing. However, research survey data such as pollock abundance from the annual summer surveys are problematic. In the 1991 Assessment the problems associated with these data were summarized as, 'in general, the survey exhibits pronounced year effects making it difficult to determine year-class strength and short-term changes in abundance in the 1991 Assessment (Annand and Beanlands 1992). The recent trend in pollock assessments has been to not use the information from RV surveys. Within the context of the Pollock Framework Assessment, our purpose here is to re-evaluate the utility of fishery-independent surveys in the estimation of abundance indices.

Interpretation of age-disaggregated indices of abundance from the summer RV surveys was confounded by strong year effects. Only very strong (e.g., 1979) or weak (e.g., 1977) year classes were detectable on a year by year basis. This was the case even when we selected a subset of strata that had historically been associated with consistent occurrence and high catch rates of pollock. However, when the age specific indices were summed over a year-class and compared with those obtained from the commercial catch rate information, there was some concurrence in the interpretation of relative strength of year classes. As a further comparison, we updated the virtual population analysis of Neilson et al. (1999) and compared with the trend in abundance of pollock as indicated from the surveys. While the areas compared were not precisely matching (the VPA covers Div 4X and 5Zc whereas the survey indices were provided for 4X), there does seem to be seem broad scale agreement between trends in the surveys and population biomass from the VPA (Fig. 23). Given this, we conclude that the survey indices should be considered as an age-aggregated index in the continued development of the Framework Assessment for this species.

Regarding the use of the ITQ survey information, the authors were less optimistic. The age composition in the most recent years (2000-2002) seems to be stable, but

other indices (RV, commercial CPUE) suggest strong recent recruitment. On the other hand, the trend in catch per tow derived from the two westernmost zones in the survey show patterns that match well. The duration of the time series is still short, and it may be that this survey will demonstrate further utility for pollock as additional data become available.

Knut Korsbrekke (an invited scientist from the Institute of Marine Research in Bergen, Norway) was presented with the RV data prior to the meeting and had looked into the possibility of removing the strong year effects in the survey. It was reasonably clear from his analysis that the strong year effects represented only some of the age-groups. A proportional year effect for all age-groups could not be assumed, but it could be worthwhile to look into this problem in more detail by analyzing only a small age range. The age range 5 to 8 is an age range where the yearclasses seem to be more consistent in their relative proportions and a proportional year effect can possibly be assumed for this age range. The estimation of a trend in yearclass abundance from the survey series would still be problematic, but it is possible that relative yearclass strength between neighbouring yearclasses could be confirmed.

Discussion (Rapporteur – D. Clark)

Meeting participants had the following observations on the bottom trawl survey data presented by the authors:

- Slow towing speed in the ITQ vessel survey may result in high escapement of pollock, given their swimming ability. This may be ameliorated in some areas by towing into the tide, but leads to inconsistencies in the ITQ survey.
- RV indices for ages 5-8: Numbers at age within a year are informative, but numbers between years are highly variable (year-effect). These ages may be useful if a smoothing among years can be determined. This would most likely be an age aggregated index – perhaps age 5+. This should be explored further.
- The proportion of bottom area in 4VW that has preferred temperature for pollock was greatly reduced in the 1990's. This may be related to reduced distribution, but it is not apparent that it would affect catchability in the survey (q).
- Figure 6 excludes 4Xmn while the others do not. It was recommended that the authors choose a consistent area in the final draft.
- It was recommended that shifts in geographic distribution of year-classes should be checked for– they may not all be in the same region, thus complicating comparisons..
- It was noted that there is a fair amount of pollock in the RV survey in 4Xmn. Something must be done to account for the pollock that are in this area.
- Data should be presented for 4Xmn and potentially adjacent RV strata in 4W to indicate there is a second area of continued abundance in the RV survey apart from 4Xopqrs5Y.
- ITQ survey may get closer to shore, but does not get enough closer to catch 'harbour pollock' (ages 1 and 2).
- ITQ survey in future analyses will be treated as recommended in the paper.

Presentation: Can Hydroacoustic Survey Approaches Yield Abundance Indices of Pollock on the Scotian Shelf?

(Presenter: J. Neilson)

Summary

Given the limitations of conventional trawl surveys and commercial fishery catch rate examination, there has been interest in developing alternative indicators of the abundance of pollock. Elsewhere in the Atlantic range of the species, countries such as Norway have employed acoustic techniques for the evaluation of pollock abundance. The same semi-pelagic, schooling life history characteristics that make pollock ill-suited for bottom trawl surveys may enhance the prospects of using hydroacoustic approaches that have been more typically used for pelagic species such as herring. Prior to the implementation of such approaches, however, it was considered desirable to investigate the biological characteristics of pollock aggregations in the Northwest Atlantic that might influence the survey design, and evaluate the potential utility of hydroacoustic methods for assessing pollock abundance. In this paper, the authors document factors that could influence the potential success of the hydroacoustic approach for pollock on the Scotian Shelf.

The authors noted that factors supporting hydroacoustic methods as an indicator of abundance include the ability to operate the vessel in a relatively high-speed search mode covering areas of known pollock aggregations. Given the propensity of pollock to aggregate in areas of particular bathymetric features, it is possible to describe an efficient survey track that would cover the newly-defined 4X5 management unit. Pollock appear to be somewhat predictable in their year to year occurrence in a given area, but not to the same extent as other schooling species such as herring. Considering the technical feasibility, Departmental and third-party software tools are available that facilitate the acquisition and editing of hydroacoustic data. Several Maritimes Region staff now have expertise with such tools, and have links with DFO staff in other regions using such software on a routine basis. The editing of the hydroacoustic signals, including separation of the fish from the bottom, appears feasible (but time consuming and sometimes difficult). Comparable results have been obtained when echograms have been re-examined by either the same scientist, or a second scientist reviewing the data independently. Using funds from the Strategic Science initiative, the pollock program has purchased three data loggers of the type deployed in the Cape John, and these hardware systems are available for use on other platforms.

On the negative side, experience with the *Teleost* surveys suggests that the aggregations are not always easily found. During the three surveys undertaken to date, considerable vessel time was spent in scouting mode, following outline surveys in areas thought by industry to be productive for pollock during the time of surveys, but often such locales proved to have no pollock. Once the aggregations were found, the authors showed that bottom trawling would be required to characterize the species and size composition. The locations of these aggregations are sometimes on bottom conditions that are difficult for bottom trawling, thus obtaining biological

samples can be problematic. The authors' results also show a tendency for the aggregations to become more available to the hydroacoustic system during the night. Other scientists and fishermen have noted that tidal influences near the mouth of the Bay of Fundy strongly influence the nature of the aggregations there, but this relationship is not well understood. The technical expertise to manage and maintain the hydroacoustic software and hardware is not available in DFO Maritimes Region, but is available from local private companies and in other Regions. To produce useful and consistent results, the acoustic systems must be calibrated each year, at a cost of about $3 K per system if these services are procured from private companies. The editing and analysis of hydroacoustic information is labor-intensive and requires skilled individuals.

In summary, while there are significant benefits in undertaking a hydroacoustic approach to generate an index of abundance for pollock, there are also very significant risks and costs. It is not clear that it is feasible to undertake a survey similar to that used as an index in Norway. A combined acoustic/trawl survey in conjunction with industry support could be feasible.

Presently, however, the resource base in scientific and technical expertise is not available within the region to undertake routine acoustic surveys, even with industry support. At a minimum, one additional professional staff member (acoustic, statistics, and biology provide support for other scientists wishing to develop and integrate acoustic techniques into their stock assessment work. A long-term funding commitment is essential to ensure success.

Discussion (Rapporteur – D. Clark)

Meeting participants offered the following conclusions on the acoustic survey information:

- Diving behaviour of saithe varies with time of day. Also, catching efficiency of the trawl (q) varies on a diel basis. Both of these will influence comparisons of acoustic estimates and concomitant trawl catches.
- Survey design – Norwegian surveys now use a systematic design with small strata in areas which are 'hotspots'. Sampling intensity is higher in these areas than in areas of low abundance.
- RV survey diel effect should be investigated with a model incorporating geographic area as well as time of day.
- Trawl and acoustics give similar results, but acoustics allows for more coverage, and coverage in areas where bottom is inappropriate for trawling.
- Bottom trawl in Norway seems to work better for cod and haddock, except for 1 and 2 year olds where large year-classes are detected better with acoustics due to vertical spreading. This survey does not cover pollock grounds and is not used as an index for pollock.
- Survey design, not the capabilities of acoustic gear, is the problem in deriving a consistent index for pollock.

- It is not feasible for DFO to undertake broad acoustic surveys in the Maritimes area. It may, however, be possible for industry to undertake focussed surveys in regions where the fishery remains active, with support from DFO.

Presentation: Alternate Indices of Abundance for Pollock, and Other Indicators of Productivity

(Presenter – J. Neilson)

Summary

There has been considerable recent interest in augmenting traditional indicators of stock productivity, such as survey abundance indices or commercial CPUE. The motivation for this appears to be related to improving the stability and reliability of models of stock condition, and to include types of information which are not usually included in the population model. Methods for incorporation of such indicators into stock assessments are still under development, but have included the so-called Traffic Light Approach (Halliday 2001) that attempts to summarize time series of various indicators of stock and ecosystem health, and integrate them into population characteristics of production, abundance, and mortality. It has been noted that indicators of stock condition were often included on intuitive grounds only, and the functional form of the relationship between the indicator and the characteristic of the population was poorly understood or unknown.

The author documented trends in potential indicators of stock productivity for pollock in Div. 4X, and when possible, attempted to relate them to trends in abundance as indicated by population model for pollock. As part of the pollock Framework Assessment in 2003, the author presented these indices as candidates for further investigation including possible incorporation in population models to be assessed during the final meeting.

The trend in weight at age and condition is striking and widespread among pollock in NAFO Div. 4X and Subarea 5. Unfortunately, we lack experimental studies such as those available for cod in the northern Gulf of St. Lawrence, where condition levels were linked with reduced reproductive success or increased mortality. Nonetheless, It may be appropriate to consider ways to reflect the current low condition of the pollock resource in population models to be developed during the next step of the pollock Framework Assessment. Comparison of residuals from stock-recruitment relationships with the condition index in a given year would seem an appropriate matter for further investigation.

While there are complications in attempting to describe the spatial extent of the fishery, the author asserted that this still might be a useful indicator to pursue. As indicated in the Working Paper of Clark et al. 2003 (this meeting) the spatial distribution has changed with a localization of the fishery in western Div. 4X and extent of the pollock fishery appears to be much reduced. There have been concerns that for schooling species, catch rates can remain misleadingly high even when the overall abundance of the stock is depleted. Given that the pollock assessment relies

upon catch rate information to a considerable extent, it would seem appropriate to consider an indicator of abundance that reflects the area over the fishery operates and experiences good catch rates.

The impact of the reduced age range on the productivity of the population could be explored using approaches similar to Marteinsdottir and Thorarinsson (1998). Those authors concluded that for Icelandic cod, the stock recruitment relationship could be improved by inclusion of a measure of spawner age diversity such as Shannon's Diversity Index. This possibility could be investigated as part of the preparations for the third meeting of the Framework Assessment.

Discussion (Rapporteur – S. Gavaris)

The distinction between indicators of the state of a resource and indicators of the productivity of a resource is important to recognize. The state of the resource pertains to the magnitude of abundance, biomass and rates of mortality for the resource. The productivity of a resource is related to its capacity to generate new growth in biomass. The processes associated with productivity, body growth, mortality and recruitment, determine the harvest strategy reference points. Indicators of the productivity of the resource can be used to adjust or qualify the decision rules that use those reference points. The FRCC plans to frame its advice for pollock in terms of these two dimensions, the state of the resource and the productivity of the resource. Classification of the productivity as low, average or high would be useful.

A Traffic Light approach was not applied to these potential indicators. This was a preliminary stage of the analysis where potential indicators were examined and an understanding of their meaning and interpretation was sought. This is considered an important step prior to attempting integration of the indicators by any method.

The trends in size at age and condition should be examined on a suitable spatial scale for homogeneity of growth, e.g. unit areas 4Xpq. It was speculated that changes in growth and plumpness may be due to re-direction of energy to earlier maturation and gonadal development. This could be caused by selective fishing pressure that removes faster growing individuals. There was some evidence for this in the Gulf of St. Lawrence cod. It was also speculated that larvae from plump fish may experience better survival, and investigation of the association between condition and recruitment success could be explored. Monitoring of changes in gonad development would require a concerted effort and extensive sampling during the spawning period.

Catch and population age composition should be summarized and examined for trends. The observed patterns could also be compared to expected equilibrium conditions under moderate exploitation. By analogy with cod where the eggs from larger females show better survival, it was speculated that a broad age structure should result in better recruitment. Larger females also spawn over a longer time period and this may enhance the chance that larvae encounter good feeding conditions. Cursory examination of the data however, do not support an association between successful recruitment and age structure. Good year-classes have arisen

from low biomass and low abundance of older pollock. Further investigation is planned.

Measures of the spatial extent of the population from survey data is difficult to interpret due to uncertainties about the reliability of the data for pollock. The area of occurrence appears to be negatively related to abundance. The survey area containing a high percentage of the catch, say 75%, could be investigated as a measure of spatial extent. While measures of spatial extent are not generally suitable as proxies of abundance, they are useful for interpreting abundance, in particular catch rates, in relation to changes in catchability. Spatial extent for pollock may be difficult to interpret because the degree of schooling behavior is associated with feeding and may be affected by variation of this activity. Spatial extent of the fishery could be examined but interpretation in relation to the population is complicated by the changing nature of the fisheries and the influence of management measures.

Direct indicators of recruitment from juvenile surveys of coastal areas are impractical because of the immense scope implied by such a sampling program. However, selected sampling may be used to monitor the range of juvenile distribution. While an early indication of recruitment success from juvenile surveys would be useful, a fishery on a recovered pollock population would not be as dependent on incoming recruitment. Information needs should not be unduly based on prevailing conditions that may be subject to change.

Productivity may be affected by habitat becoming unavailable. Pollock do not appear to tolerate cold water temperatures. Historically, some purse seining of pollock has occurred and this may be related to temperatures in the water column. It may be useful to investigate changes in available habitat relative to production. Changes in available habitat could also result in changes in density and thereby affect density dependent processes.

It was suggested that the availability of prey, in particular herring, should be examined in relation to condition and recruitment success. The availability of red feed, krill, was noted as a seasonal phenomenon, occurring about June and July. When red feed descends, pollock are more easily caught on fishing grounds with good bottom. Care should be taken in interpreting diet studies to account for such seasonal phenomena.

It was speculated that an increase in the abundance of predators, such as seals, may have an impact on pollock productivity. Potential relationships between pollock recruitment or mortality and predator abundance were not examined.

PART #3 – MEETING OF 6-8 APRIL 2004
POPULATION SYNTHESIS

Conference Centre, SABS
St. Andrews, New Brunswick

The intent of the final meeting was to identify the best approach for synthesizing the available fishery and indices of abundance into a description of stock status. More specifically, the remit of the meeting was to address the following:

- Methods for integrating information on stock status, including current assessment approaches and alternatives.
- Approaches for the evaluation of the consequences of alternative TAC options in relation to the management plan.
- Determination of the appropriate reference points for this resource.
- Determination of the future assessment plan.

The agenda for the meeting appears in Appendix 3 and a list of resource documents made available to meeting participants is shown in Appendix 4. The participants in the meeting are shown in Appendix 7. Erin Carruthers served as rapporteur for the meeting.

Presentation: Background and Summary of Progress in the First Two Meetings
(Presenter – J. Neilson)

Summary

The presentation provided an overview of key aspects of the biology of pollock, recognizing that some meeting participants may not be completely familiar with the biology of pollock, and may not have been present during the first two meetings.

The presentation also provided an overview of the most important features of pollock biology, as they relate to the synthesis of stock status. It was pointed out that pollock has a unique life history that has some implications for how the assessment is done. For example, pollock have a coastal juvenile life history stage that appears to be obligate. Pollock also tend to form size and age-dependent schools, and appear in the midwater environment to a greater extent than do other gadids such as haddock and cod.

Progress made during the first two meetings of the Framework Assessment was reviewed. The discussions of stock structure during Meeting 1 concluded that future stock assessments should explicitly deal with both the eastern and western pollock stock components on the Scotian Shelf. Available data did not allow a precise resolution of the boundary between the eastern and western components. Unit areas 4Xm and 4Xn show affinity with the slower-growing eastern component, and calculation of the catch at age and indices should reflect this. The current eastern

and northern boundaries with NAFO Divs. 4T and 3Ps appear appropriate and should be retained. The boundary of the stock to the south in SA 5 appeared less clear. The suggestion that the International Boundary form the limit of the management unit was based more on operational considerations rather than considerations of stock distribution.

The results of Meeting 2 (description of the fishery and indices of abundance) was then summarized. It was concluded that the level of sampling in relation to landings was generally adequate, with the exception of the Bay of Fundy area. The indices of abundance accepted for inclusion in the population model included a mobile gear catch rate series (as used in previous assessments, with slight modifications), a newly developed gillnet catch rate series, and the summer RV surveys. The latter index of abundance has not been used in recent assessments, but participants in the Framework Assessment agreed that while the survey series is imprecise, it appears to have value. The presentation concluded with a "report card" that summarized the status of knowledge. It was argued that the pollock stock assessment had a good foundation in stock structure, age determination, and fishery sampling. It was somewhat weaker in other aspects of the biological understanding of the resource relative to other gadid species. It was considered to have a particular weakness with regard to indices of abundance.

Discussion

Participants had a few background questions regarding effort measures, age length keys and and selectivity of gear. It was established that changes in gear (from diamond to square mesh) were included as a factor in the catch rate analysis and that different age-length keys were used each trimester in the proposed management area.

Some questions regarding the boundaries of the proposed western stock unit were raised at this point. For example, the different CPUE trends between 4Xo and the rest of the stock unit were noted. However, possible explanations for this difference related to fishing practices instead of pollock abundance were put forward. For example, much of the pollock caught in recent years was part of a mixed fishery and the movement of the fleet west may be more related to the desired mix of cod, haddock or redfish required by the fleet. Also, pollock levels in this region were always low and with more restrictive management measures, effort was focussed in areas of higher abundance. Further, it was noted that although the overall TAC may not have be reached by the fleet, the TAC may be limiting for individuals especially those that direct for pollock. Industry representatives said some shifts in fishing patterns were expected in the 1990's, since there was a shift to use of Individual Transferable Quotas in 1991.

It was noted that the boundary with the USA is "porous" and this may be contributing to some of the uncertainty. Later in the meeting it was suggested that given the concentration of Canadian and American pollock catches along the Hague Line, some consideration should be given as to whether this resource is a transboundary issue and could be assessed through the TRAC process.

Presentation: Pollock Stock Status in the Canadian Maritimes: A Framework Assessment
(Presenters: John Neilson, Peter Perley, Stratis Gavaris)

The authors discussed initial ADAPT formulations that included RV and CPUE indices examined separately, because initial examination of "smoothed" trends suggested that the RV showed a more pronounced decline

These initial models had the same assumptions and were used for aggregated and disaggregated indices, i.e. only one terminal year-class was estimated and the partial recruitment factors for the remaining year-classes were calculated from the fishing mortality matrix. The authors noted that residual diagnostics for the "CPUE only" run suggest substantial lack of fit with severe trends in residuals consistent with the suspicion that CPUE is hyper-stable and not proportional to abundance. Residual diagnostics for the RV formulation also indicate time-trended residuals, but the pattern is somewhat less severe.

The authors noted that there was a tendency for catchability at age to be dome shaped for CPUE, and catchability for both CPUE and RV increases until about age 6. For both formulations using either RV or CPUE indices, the resulting population was similar for aggregated or disaggregated, but the precision of the year-class estimate was better for dis-aggregated, suggesting that there was useful information on age structure in the disaggregated data.

The authors concluded that age structured indices provide some information and stability, that the assumption of constant proportional catchability for CPUE for the 1982-2002 period should be rejected, disaggregated RV results suggest that age 3 and 4 are more variable, and the early years of RV information show lack of fit.

Presentation: Summary of Index Analyses for Pollock
(Presenter: Alan Sinclair)

A number of stock indicators were derived directly from research vessel survey (RV) and commercial catch per unit effort (CPUE) time series for Pollock in 4Xopqrs, 5Zc and 5Yb. While the RV results appeared to be more variable, there was good agreement in year-class size estimates and total mortality estimates from these independent data sources. Comparison of the two time series suggested that the CPUE series was not proportional to stock size, but rather hyperstable (CPUE did not decline proportionally to population decline). Recruitment to the CPUE series appeared to be dome-shaped with young (age 3-4) and older (age 7-10) fish being less represented than mid-aged fish.

Both the RV and CPUE indices indicate declining abundance of older fish (7+) in the population. This trend has been present since the 1980s. The abundance of younger fish (ages 4-6) was relatively stable throughout the 1980s and early 1990s, but their abundance appears to have declined in recent years.

There has been a considerable increase in total mortality since the mid-1980s. While fishing mortality may have increased in the late 1990s and early 2000s, there was no apparent trend in fishing mortality in the late 1980s. This suggests there may have been an increase in natural mortality during this time period.

During the meeting, similar techniques were used to analyse RV data from the 4VWXmn area. The results indicated similar trends in year-class size and total mortality. Total mortality reached a high of 2 in the most recent time period.

Presentation: Retrospective Analyses
(Presenter: Ralph Mayo)

Retrospective analyses were conducted using the full suite of tuning indices and on each of the 4 index series (RV, Small Mobile, TVRP, and Gill net fleets). The commercial catch at age was reduced from the full age range by imposing a 10+ group in the calculations. In all cases, surviving terminal population numbers in 2003 were estimated for ages 3 through 9. F on the oldest was derived by a stock-weighted average of the F's on ages 7 through 9.

The analyses revealed severe retrospective patterns in F and total stock biomass that were consistent among the four tuning series. There was a strong tendency in all cases to underestimate F and overestimate biomass in the terminal year. Trends in stock biomass were similar when each of the four tuning fleets was employed individually. However, the RV tuning series alone resulted in estimates of F that remained relatively high in 2001 and 2002 compared to estimates obtained from the commercial tuning series.

The CVs on the estimated population numbers ranged from 30-60% when the full suite of tuning indices was included to 70-120% when only a single tuning fleet was employed. It was agreed that the retrospective analyses were useful in a qualitative way to illustrate potential discrepancies, but they were not indicative of the performance of the VPA model as formulated in the final framework.

Presentation: An Untuned VPA as a Diagnostic Tool
(Presenter - Don Clark)

In a heavily exploited stock where the catch is well sampled, the catch at age should be a good indication of relative year-class strengths in the population. For pollock, exploitation has been high, there are few ages in the catch, and partial recruitment patterns appear to have been quite consistent. By age 8 or 9 each cohort is almost fished out. By assuming a low population on a cohort which is almost eliminated, the population for that cohort can be back-calculated. The adjacent younger cohort can then be determined relative to the population of a 'known' cohort, using the relative catch for each and the partial recruitment estimates from the VPA. This linkage can be made as far back in time as practical, thus reducing the importance of the terminal

population estimate for the 'known' cohort. Estimating the population at age 5 relative to the population at age 6 for the 'known' cohort was done for pollock.

Estimates from this method are volatile, since small changes in PR will multiply through subsequent cohort estimates. It does, however, provide an estimate which is free from the influence of the available indices, which show large inter-annual variability. This produced an estimate of current population abundance which is similar to that for the 'constrained' VPA tuned to RV and catch rate indices. Abundance at age 2 for the 1997-99 yearclasses are estimated to be quite similar from an untuned VPA.

It was proposed that results from an untuned VPA may be useful to consider if population estimates from a tuned VPA appear inconsistent with commercial catch in the terminal year and result in a trend in estimated PR for which there is no clear explanation.

Presentation: Biomass-Related Reference Points for Pollock
(Presenter: Bob Mohn)

An analysis of surplus production of the pollock was presented to aid in the definition of biomass related reference points. Examination of a plot of surplus production (annual change in biomass plus yield) showed that when biomass was lower than 30,000 t that the production tended to be lower than when it was above. The P/B ratio shows that the P/B for this resource is high in recent years but that the production is low because the biomass is low.

An analysis of potential growth over one generation was performed which used moving windows of data. This looks at average growth, natural mortality and recruitment in moving windows of data from the VPA. See Mohn and Chouinard, Production analysis of southern Gulf of St. Lawrence cod for the identification of biological reference points. CSAS (MS in prep) for more details. This work showed that the pollock could increase by about 200% over one generation. This high rate of potential growth is explained by the difference between the instantaneous growth rate and natural mortality. Recalling that the assumed natural mortality is 0.2, the growth rate for ages 2-4 is about 3 times as high while for age 5-7 it is almost double the natural mortality in recent years.

Discussion of Presentations Related to Current Status

Participants suggested improvements to the population model presented by Neilson and coworkers, using a power function between the commercial CPUE index and the population numbers to reflect hyperstabiity as well as a dome-shaped relationship between catchability and age.

Emigration between the proposed management area and the eastern region (4VWXmn) was suggested as a possible reason for the apparent increase in natural mortality. However, when similar analyses of the eastern region also showed an

increase in mortality, this hypothesis was rejected. Two other possible explanations for the increase in natural mortality were noted: possible change in fishing practices and decreased condition of pollock during this period. Neither was resolved.

The consensus of the review was that the initial model results presented by the authors in the working paper were too heavily constrained. The meeting adjourned to allow participants time to investigate various model options. Upon reconvening and discussing the interim results and the presentations summarized previously, the following model formulation and conclusions were reached as a consensus:

- Fishery landings information and sampling from the fishery for length/age composition is considered reliable for the period from 1982 to the present and suitable to characterize the catch at age. (from meeting 2)

- Catch rates derived from a selected pollock directed subset of the OTB TC 1-3 fishery and bottom trawl survey abundance indices showed concordance with respect to general abundance trends, year-class strengths and mortality rates. The bottom trawl survey results displayed high variability and the fishery catch rates showed hyperstability. Recognizing these caveats, both indices of abundance were considered suitable for estimation of status.

- Investigation of changes in natural mortality suggested that there may have been an increase in natural mortality from about the late 1980s or early 1990s until the mid 1990s, but results were inconclusive. Resolution of change in M from VPA calibration was not possible due to variability in the indices and confounding with other estimated parameters. Therefore M was assumed constant over age and years for VPA analysis.

- Estimates of population abundance in numbers at the beginning of the year following the terminal year (the last year for which catch at age is available) are obtained by calibrating a Virtual Population Analysis with the two indices of abundance, the bottom trawl survey and the pollock directed OTB TC1-3 catch rates. The following formulation produced results that were consistent with observations and expected biological and fishery processes (a indexes age and y indexes year):

Observations

$C_{a,y}$ = catch at age for a = 2 to 12 and y = 1982 to terminal year.
$I_{1,a,y}$ = bottom trawl survey for a = 3 to 8 and y = 1984 to terminal year.
$I_{2,a,y}$ = catch rates for a = 3 to 8 and y = 1982 to terminal year.
Both the bottom trawl survey and catch rates are related to the middle of year VPA abundance.

Parameters

$\theta_{a,y}$ = *ln* abundance for a=4 to 10 in y=terminal year +1.
$\kappa_{1,a}$ = *ln* bottom trawl survey catchability for a = 3 to 8.

$\kappa_{2,a}$ = *ln* catch rate catchability for *a* = 3 to 8.
$\beta_{2,a}$ = power for catch rate catchability relationship for *a* = 3 to 8.

Model Structural Assumptions

- Natural mortality was assumed to be 0.2 for all ages and years.
- Abundance at ages 11, 12 and 13 in the terminal year and at age 13 for years 1995 until the terminal year was assumed to be a small number (1000).
- Fishing mortality on age 12 for 1982 to 1994 was assumed to be equal to the population number weighted average fishing mortality on ages 9, 10 and 11.
- The biomass for ages 4+ is considered a proxy for spawning biomass.

Error Model

- Catch at age error was assumed negligible compared to the index error.
- Error on the *ln* index observations was assumed to be independent and identically distributed.

Estimation

Parameters were obtained by minimizing the objective function
$\sum_{i,a,y}\left(I_{iay} - \hat{I}_{iay}[\theta,\kappa]\right)^2$
where $\hat{I} = \kappa' N$ for the bottom trawl survey
and $\hat{I} = \kappa' N^{\beta}$ for catch rates
and $\kappa = \ln \kappa'$.

Characterization of Productivity to Determine Harvest Strategy

Yield per recruit analysis was coupled with stock-recruitment patterns to evaluate age structured productivity and to derive a fishing mortality reference point. The value of F_{ref} = 0.2 was considered a practical limit fishing mortality threshold. When stock biomass is depleted, exploitation may be further constrained to achieve rebuilding. Historically, the chance of good recruitment has been higher when the adult biomass is greater than a B_{ref} = 30,000 t threshold. This reference reflects the biomass below which reduced production and recruitment was observed. This biomass reference point is based on a limited biomass range during a period of high exploitation and does not take into account that production in this stock may have been higher prior to 1982.

Procedure for Projection

For short term projections, catch and stock weights at age and partial recruitment to the fishery should be averaged over a recent period of stable patterns if there are no trends over time. If trends are detected, suitable measures to reflect the most recent patterns should be applied. Alternative TAC tactics are evaluated through risk analysis. The risk of F exceeding F_{ref} should generally be neutral to risk averse (less

than 50%) and the risk of biomass decline(change in B < 0) should be neutral to risk averse (less than 50%) when biomass is less than B_{ref} = 30,000t. The further biomass is below 30,000t, the decisions should be more risk averse. These risk evaluations are conditioned on the model assumptions. The meeting noted that the current model indicates that the 2002 biomass level is below this threshold.

The meeting participants also considered the current lower limit of 43 cm implemented to discourage wastage. The group considered that it would be useful to compare the percentage of small pollock between the observer and logbook data for both large and small meshes.

Considering the objective of minimizing disturbance during spawning (part of the objectives for the Fisheries Management Plan for pollock), this has not been a feature of pollock management in the past. Currently, the pollock fishery is focussed in the summer when pollock are not spawning. The previous large dragger fishery component was a winter fishery. It was suggested that at the next assessment, further consideration of this issue could be presented..

Procedure for Assessing the Eastern Component (4VW + 4Xmn)

Meeting participants agreed that it would be possible to provide approximate guidance on acceptable levels for exploitation of the eastern component by first conducting an assessment of the western component, and investigate survey biomass ratios between the eastern and western components as a means to identify a TAC for the east. However, it was noted that Z calculations for the survey indicate a very high total mortality for the eastern component in recent years. Taking into consideration this observation and the slower growth rate of this population, it seems likely that there is no scope for exploitation for this population at present. The fall assessment will investigate this situation more thoroughly.

Future Assessment Plan

- Participants next considered what would trigger another Framework Assessment.
- Two important considerations for a new Framework Assessment are either new data or poor model diagnostics.

Comments on the Framework Assessment Approach and Concluding Remarks

Meeting participants were asked to offer their views on the sequential approach used for the Framework Assessment. While most felt the process was thorough and yielded a useful result, one participant noted that a workshop venue might offer more scope for detailed examination of the data. Another participant expressed concern that industry was somewhat poorly represented in the current meeting. Others noted that with the sequential approach, industry's involvement was more critical in the earlier stages dealing with stock structure, the description of the fishery and abundance indices. Finally, it was noted that the current population model reflects a considerable change in our perception of the state of this resource. It was noted that there is a need to meet with the fishing industry before the fall RAP to introduce the

results of the model and to help the industry better understand the implications of the new approach.

The Chairman concluded the meeting by thanking all participants for their active participation.

LITERATURE CITED

Annand, C., and D. Beanlands. 1992. Assessment of pollock (*Pollachius virens*) in NAFO Divisions 4VWX and Subdivision 5Zc for 1991. CAFSAC Research Document 92/44, 44 p.

Halliday, R.G. (Chairman). 2001. Proceedings of the Fisheries Management Studies Working Group, 15-16 and 31 May 2001, Bedford Institute of Oceanography, Dartmouth, Nova Scotia. CSAS Proc. Ser. 2001/21, 82pp.

Marteinsdottir, G., and K. Thorarinsson. 1998. Improving the stock-recruitment relationship in Icelandic cod (*Gadus morhua*) by including age diversity of spawners. Can. J. Fish. Aquat. Sci. 55: 1372-1377.

Neilson, J.D., P. Perley, C. Nelson, T. Johnston, and K. Zwanenburg. 1999. The 1999 assessment of pollock (*Pollachius virens*) in NAFO Divisions 4VWX and Subdivision 5Zc. CSAS Res. Doc. 99/160, 77 p.

Neilson, J.D., P. Perley, E.H. Carruthers, W.T. Stobo, and D. Clark. 2003. Stock structure of pollock in NAFO Divs. 4VWX5Zc. CSAS Res. Doc. 2003/045, 55 p.

APPENDIX 1.

Pollock Framework Assessment
Agenda, Meeting 1 (Biology and Stock Structure)
St. Andrews Biological Station

May 1, 2003

0900-0915 – Welcome, Introductions and Review of Terms of Reference by the Chairperson (R. Stephenson)

0915-0945 – Objectives Based Fisheries Management and Framework Assessments (R. O'Boyle)

0945 – 1015 – Overview of pollock biology (J. Neilson)

1015 – 1035 – Break

1035 – 1130 - Decadal shifts in the diet and growth of pollock on the Scotian Shelf and the Bay of Fundy (E. Carruthers).

1130 – 1200 – Stock structure of pollock in the Northwest Atlantic (J. Neilson)

1200 –1300 – Catered lunch provided onsite.

1300 – 1700 – Stock structure of pollock in the Northwest Atlantic (cont), including review of conclusions and development of consensus position.

APPENDIX 2.

Pollock Framework Assessment
Agenda, Meeting 2 (Fishery and Abundance Indices)
St. Andrews Biological Station

June 16-18, 2003

June 16

1300-1315 – Welcome, introductions, and appointment of rapporteurs (R. Stephenson)

1315-1330 – Review of progress, goals of the current meeting, and plans for the future (J. Neilson)

1330 –1500 – Description of the pollock fishery. (D. Clark)

1500 – 1520 – Break

1520 – 1540 -- Review of commercial fishery sampling for pollock (J. Neilson).

1540 – 1630 – Pollock bycatch in the redfish fishery (T. McIntyre)

June 17

0900 – 1000 – Evaluation of commercial fishery catch rates as indices of abundance (Neilson, Fowler).

1000 –1020 – Break

1020 – 1200 – Discussion of commercial fishery catch rate paper.

1200 – 1315 – Lunch

1315 – 1415 – Evaluation of RV and ITQ survey indices (Carruthers)

1415 -- 1500 – Discussion of RV/ITQ paper.

1500 – 1520 – Break

1520 – 1620 – Feasibility of using hydroacoustic approaches for abundance indices of pollock

1620 – 1630 – Identification of follow-up items for tabling tomorrow (R. Stephenson).

June 18

0900 – 1000 – Alternate indices of abundance for pollock.and other indicators (J. Neilson)

1000 – 1020 – Break

1020 – ?? – Presentation of extra analyses, review of draft report, adjournment.

APPENDIX 3.

Pollock Framework Assessment
Agenda, Meeting 3 (Population Synthesis)
St. Andrews Biological Station
April 6-8, 2004

April 6

0900 – 0915 – Welcome, introductions, and appointment of rapporteur (R. Stephenson).

0915 – 1000 – Review of Biology of Pollock and Progress With First Two Meetings (J. Neilson).

1000 – 1020 – Break

1020 – 1100 – Pollock Stock Status in the Canadian Maritimes. (J. Neilson, P. Perley, S. Gavaris).

1100 – 1130 – Stock Indicators Derived From Indices. (A. Sinclair).

1130 – 1145 – Retrospective analyses, by Index Fleet. (R. Mayo).

1145 –1200 – An untuned VPA approach (D. Clark).

1200 – 1330 – Lunch

1330 – 1400 – Delay-difference modeling approaches (A. Sinclair).

1400 – 1500 – Discussion of Working Papers and Identification of Options for Further Analysis.

1500 – Break

End of meetings for first day, balance of day to be used for further analyses.

Please also note that a dinner at a local restaurant is available for interested participants at 7:00 PM.

April 7

1000 – ? – Presentation and evaluation of additional work, identification of further requirements.

Balance of day to be used for further analyses

April 8

1000 – ? – Finalize proceedings, including the consensus on the preferred method for description of current status, and development of the future assessment plan.

APPENDIX 4.

Pollock Framework Assessment Meeting 3
Resource Documents

For Review

WP 1. Pollock Stock Status in Canadian Maritime Waters. Authors: Neilson, Perley, Gavaris.

WP 2. Stock Indicators Derived From Indices. Author: Sinclair.

Record of Past Framework Meetings

Draft Proceedings, Framework Meetings 1 and 2. Author: Stephenson.

Other Background Documentation (limited copies made, more can be provided)

Stock Structure

Neilson, J.D., P. Perley, E.H. Carruthers, W. Stobo, and D. Clark. 2003. Stock structure of pollock in NAFO Divs. 4VWX5Zc. CSAS Res. Doc. 2003/045, 56 p.

Age Determination

Neilson, J.D., W.T. Stobo, and P. Perley. 2003. Age and growth of Canadian East Coast pollock: comparison of results from otolith examination and mark-recapture studies. Trans. Am. Fish. Soc. 132: 536-545.

Fishery Description and Catch at Age

Clark, D., P. Perley, J. Hinze, and J. Neilson. 2004. A summary of fishery and sampling information for pollock. CSAS Working Paper, April 2004.

Biology

Carruthers, E.H., J.D. Neilson, K. Waters, and P. Perley. 2004. Long-term changes in pollock (*Pollachius virens*) feeding on the Scotian Shelf: responses to a dynamic ecosystem. J. Fish. Biol. (UK) accepted.

Neilson, J.D., D. Clark, G.D. Melvin, P. Perley, and C. Stevens. 2003. The diel-vertical distribution and characteristics of pre-spawning aggregations of pollock (*Pollachius virens*) as inferred from hydroacoustic observations: the implications for survey design. ICES Journal of Marine Science 60:1-12.

Neilson, J.D., L. Annis, P. Perley, A. Clay, C. Croft, and M. O'Connor. 2002. Seasonal aggregations of Canadian east coast pollock as inferred from the

commercial fishery and hydroacoustic observations. J. Fish. Biol. (UK) 61:1067-1084.

Indices of Abundance

Carruthers, E.H., J.D. Neilson, P. Perley, D. Clark, and S. Smith. 2003. Evaluation of research vessel and ITQ survey data as abundance indices for pollock. CSAS Res. Doc. 2003/110, 40 p.

Neilson, J.D. 2003. Potential indicators of pollock productivity. CSAS Res. Doc. 2003/111, 14 p.

Neilson, J.D., P. Perley, M. Fowler, and D. Clark. 2003. An evaluation of commercial fishery catch rates as an index of abundance for pollock in NAFO Divs. 4X5. CSAS Res. Doc. 2003/109, 50 p.

Last Full Assessment

Neilson, J.D., P. Perley, C. Nelson, T. Johnston, and K. Zwanenburg. 1999. The 1999 Assessment of pollock (*Pollachius virens*) in NAFO Divisions 4VWX and Subdivision 5Zc. Canadian Stock Assessment Secretariat Research Document 98/144, 77 p.

Last Stock Status Report

DFO, 2002. Updates on selected Scotian Shelf groundfish stocks in 2002. DFO Science Stock Status Report A3-35(2002), 30 p.

APPENDIX 5.

Participants in Meeting #1

Name	Affiliation/Address
Wayne Stobo	DFO/MFD/BIO
Erin Carruthers	DFO/MFD/SABS
Kent Smedbol	DFO/MFD/SABS
Mike Power	DFO/MFD/SABS
Bruce Chapman	FRCC
Gary Melvin	DFO/MFD/SABS
Peter Perley	DFO/MFD/SABS
Cecil Nelson	DFO/MFD/SABS
Clary Reardon	NS Dept. Agriculture & Fisheries
Lou Van Eeckhaute	DFO/MFD/SABS
Heath Stone	DFO/MFD/SABS
Jorgen Hansen	DFO/FRM/BIO
Jean Guy d'Entremont	FRCC
Ralph Mayo	NMFD/NOAA/Woods Hole, Mass
Stratis Gavaris	DFO/MFD/SABS
Bob O'Boyle	DFO/Science/BIO
Rob Stephenson	DFO/MFD/SABS
Joe Hunt	DFO/MFD/SABS
Donald Clark	DFO/MFD/SABS
Marc Johnston	NB DAFA – St. George, NB
Ron Cronk	NB DAFA – Grand Manan, NB
Jennifer Hinze	DFO/MFD/SABS
Christa Waters	DFO/MFD/SABS
Lei Harris	DFO/MFD/SABS
Kirsten Clark	DFO/MFD/SABS
Stacey Paul	DFO/MFD/SABS
Matt Litvak	UNBSJ

APPENDIX 6.

Participants in Meeting #2

Name	Affiliation/Address
Peter Perley	DFO/MFD/SABS
Erin Carruthers	DFO/MFD/SABS
Heath Stone	DFO/MFD/SABS
Mark Fowler	DFO/MFD/BIO
Tara McIntyre	DFO/MFD/BIO
Doug Swain	DFO/GFC
Stratis Gavaris	DFO/MFD/SABS
Lei Harris	DFO/MFD/SABS
Donald Clark	DFO/MFD/SABS
Cecil Nelson	DFO/MFD/SABS
Chris Gregan	Barry Group Inc.
Christine Penney	Clearwater Seafoods
Jorgen Hansen	DFO/FRM/BIO
Brian Giroux	Scotia Fundy Mobile Gear Assoc.
Hubert Saulnier	MFU Fundy Fixed Gear Council
Jean Guy d'Entremont	FRCC
John Neilson	DFO/MFD/SABS
Knut Korsbreddie	IMR, Bergen, Norway
Ron Cronk	NB DAFA, Grand Manan, NB
Clary Reardon	NS Dept. Agriculture & Fisheries
Marc Johnston	NB DAFA, St. George, NB
Stacey Paul	DFO/MFD/SABS
Rob Stephenson	DFO/MFD/SABS

APPENDIX 7.

Participants in Meeting #3

Meeting 3 participants, from left to right: Kent Smedbol, Rob Stephenson, Bill de la Mare, Cecil Nelson, Don Clark, Christine Penney, Chris Gregan, Clary Reardon, Jon Hansen, John Neilson, Peter Perley, Alan Sinclair, Stratis Gavaris, Erin Carruthers, Ralph Mayo, Bob Mohn (photo credit: Mike Power).