14 Pollock

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This assessment of the pollock (Pollachius virens) stock is an operational assessment of the existing 2014 operational assessment (Hendrickson et al. 2015). This assessment updates commercial and recreational fishery catch data, research survey indices of abundance, the ASAP analytical models, and biological reference points through 2014. Additionally, stock projections have been updated through 2018. In what follows, there are two population assessment models brought forward from the 2014 operational assessment: the base model (dome-shaped survey selectivity), which is used to provide management advice; and the flat sel sensitivity model (flat-topped survey selectivity), which is included for the sole purpose of demonstrating the sensitivity of assessment results to survey selectivity assumptions. The most recent benchmark assessment of the pollock stock was in 2010 as part of the 50th Stock Assessment Review Committee (SARC 50; NEFSC 2010), which includes a full description of the model formulations.

State of Stock: The pollock (*Pollachius virens*) stock is not overfished and overfishing is not occurring (Figures 71-72). Retrospective adjustments were made to the model results. Retrospective adjusted spawning stock biomass (SSB) in 2014 was estimated to be 154,919 (mt) under the base model and 32,040 (mt) under the flat sel sensitivity model which is 147 and 58% (respectively) of the biomass target, an SSB_{MSY} proxy of SSB at $F_{40\%}$ (105,226 and 54,900 (mt); Figure 71). Retrospective adjusted 2014 age 5 to 7 average fishing mortality (F) was estimated to be 0.07 under the base model and 0.233 under the flat sel sensitivity model, which is 25 and 92% (respectively) of the overfishing threshold, an F_{MSY} proxy of $F_{40\%}$ (0.277 and 0.252; Figure 72).

Table 45: Catch and status table for pollock. All weights are in (mt), recruitment is in (000s), and F_{AVG} is the age 5 to 7 average F. Unadjusted SSB and F estimates are reported. Model results are from the current base model and flat sel sensitivity model.

	2007	2008	2009	2010	2011	2012	2013	2014
Data								
Commercial landings	8,373	10,040	7,504	5,153	7,211	6,742	5,058	4,545
Commercial discards	157	355	280	97	174	108	168	135
Recreational landings	570	918	576	1,326	1,436	582	1,727	612
Recreational discards	181	903	395	797	917	845	1,641	779
Catch for Assessment	9,281	12,216	8,755	7,373	9,738	8,277	8,594	6,071
Model Results (base)								
Spawning Stock Biomass	282294	271102	250598	228732	225714	209493	205977	198847
F_{AVG}	0.047	0.075	0.066	0.064	0.085	0.072	0.073	0.051
Recruits *age*1	23331	27177	15360	26638	34890	71958	41112	59953
Model Results (flat sel sensitivity)								
Spawning Stock Biomass	81862	78556	69440	63044	62441	57973	57020	57327
F_{AVG}	0.119	0.188	0.168	0.163	0.223	0.192	0.2	0.133
Recruits *age*1	11029	12879	7384	12954	17235	36001	20880	31234

Table 46: Comparison of biological reference points for pollock estimated in the 2014 assessment and from the current base model and flat sel sensitivity model. An F_{MSY} proxy of $F_{40\%}$ was used for the overfishing threshold, and was based on long-term stochastic projections. F_{MSY} is reported as the age 5 to 7 average F. Recruits represent the median of the predicted recruits. Intervals shown are 5^{th} and 95^{th} percentiles.

	2014 base	2014 flat sel sensitivity	base	flat sel sensitivity
F_{MSY}	0.273	0.245	0.277	0.252
SSB_{MSY} (mt)	76,879	51,140	105,226 (81,994 - 139,721)	54,900 (40,655 - 74,922)
MSY (mt)	14,791	10,491	19,678 (14,443 - 28,533)	10,995 (7,757 - 15,975)
Median recruits (age 1) (000s)	17,622	10,806	25,299	12,879
Overfishing	No	Yes	No	No
Overfished	No	No	No	No

Projections: Short term projections of median total fishery yield and spawning stock biomass for pollock were conducted based on a harvest scenario of fishing at an F_{MSY} proxy of $F_{40\%}$ between 2016 and 2018. Catch in 2015 has been estimated at 5,208 (mt). Recruitments were sampled from a cumulative distribution function derived from ASAP estimated age 1 recruitment between 1970 and 2012. Recruitments in 2013 and 2014 were not included due to uncertainty in those estimates. The annual fishery selectivity, natural mortality, maturity ogive, and mean weights used in projections are the most recent 5 year averages. Retrospective adjusted age 5 to 7 average F in 2014 fell outside the 90% confidence intervals of the unadjusted 2014 value under the base model (Figure 72). Retrospective adjusted SSB and age 5 to 7 average F in 2014 fell outside the 90% confidence intervals of the unadjusted 2014 values under the flat sel sensitivity model (Figures 71-72). Therefore, retrospective adjustments were applied in the projections for the base model and the flat sel sensitivity model.

Table 47: Retrospective adjusted short term projections of median total fishery yield and spawning stock biomass for pollock from the current base model and flat sel sensitivity model based on a harvest scenario of fishing at an F_{MSY} proxy of $F_{40\%}$ between 2016 and 2018. Catch in 2015 has been estimated at 5,208 (mt). F_{AVG} is the age 5 to 7 average F.

Year	Catch (mt)	SSB (mt)	F_{AVG}	Catch (mt)	SSB (mt)	F_{AVG}
		base			*flat sel sensitivity*	
2015	5,208	160,581	0.056	5,208	42,924	0.167
2016	27,668	178,534	0.277	9,154	51,426	0.252
2017	30,704	176,077	0.277	11,303	56,807	0.252
2018	31,327	168,611	0.277	12,572	58,890	0.252

Special Comments:

- What are the most important sources of uncertainty in this stock assessment? Explain, and describe qualitatively how they affect the assessment results (such as estimates of biomass, F, recruitment, and population projections).

  The largest source of uncertainty in the pollock assessment is selectivity, as the base model with dome-shaped survey and fishery selectivities implies the existence of a large cryptic biomass that neither current surveys nor the fishery can confirm. If it is assumed that flat-topped survey selectivities lead to lower estimates of SSB and higher estimates of F (Figures 71-72), then stock status is insensitive to the shape of the survey selectivity patterns at older ages.

- Does this assessment model have a retrospective pattern? If so, is the pattern minor, or major? (A major retrospective pattern occurs when the adjusted SSB or F_{AVG} lies outside of the approximate joint confidence region for SSB and F_{AVG}; see Table 8).

  The 7-year Mohn's ρ, relative to SSB, was 0.291 under the base model and 0.66 under the flat sel sensitivity model in the 2014 assessment and was 0.284 and 0.789, respectively, in 2014. The 7-year Mohn's ρ, relative to F, was -0.252 under the base model and -0.359 under the flat sel sensitivity model in the 2014 assessment and was -0.276 and -0.43, respectively, in 2014. There was a major retrospective pattern for the base model because the ρ adjusted estimate of 2014 F (F_ρ=0.07) was outside the approximate 90% confidence region around F (0.035 - 0.066). There was a major retrospective pattern for the flat sel sensitivity model because the ρ adjusted estimates of 2014 SSB (SSB_ρ=32,040) and 2014 F (F_ρ=0.233) were outside the approximate 90% confidence region around SSB (37,243 - 77,410 (mt)) and F (0.084 - 0.182). A retrospective adjustment was made for both the determination of stock status and for projections of catch in 2016. The base model retrospective adjustment changed the 2014 SSB from 198,847 to 154,919 and the 2014 F_{AVG} from 0.051 to 0.07. The flat sel sensitivity model retrospective adjustment changed the 2014 SSB from 57,327 to 32,040 and the 2014 F_{AVG} from 0.133 to 0.233.

- Based on this stock assessment, are population projections well determined or uncertain?

  Population projections for pollock appear to be reasonably well determined for both the base model and the flat sel sensitivity model.

- Describe any changes that were made to the current stock assessment, beyond incorporating additional years of data and the affect these changes had on the assessment and stock status.

  Only one major change was made to the pollock assessment as part of this update. Likelihood constants were excluded from likelihood calculations to avoid potential bias caused by one of the recruitment likelihood constants, which is the sum of the log-scale predicted recruitments, and therefore not a constant. Inclusion of this likelihood constant allows the assessment model to minimize the negative log likelihood by estimating lower recruitments. Exclusion of the likelihood constants led to higher estimates of SSB and lower estimates of F (Figures 71-72).

- If the stock status has changed a lot since the previous assessment, explain why this occurred.

  Stock status based on the base model has not changed since the previous assessment. Stock status based on the flat sel sensitivity model has changed from 'overfishing is occurring' in the previous assessment to 'overfishing is not occurring' in the current assessment. However, the retrospective adjusted 2014 age 5 to 7 average fishing mortality

from the flat sel sensitivity model (0.233) is close to the F_{MSY} proxy (0.252). This change in status likely is due to a decline in predicted F from 2013 to 2014, as well as to the exclusion of the likelihood constants, which led to higher predicted stock productivity.

- Indicate what data or studies are currently lacking and which would be needed most to improve this stock assessment in the future.

  The pollock assessment could be improved with additional studies on gear selectivity. These studies could cover topics such as physical selectivity (e.g., multi-mesh gillnet), behavior (e.g., swimming endurance, escape behavior), geographic and vertical distribution by size and age, tag-recovery at size and age, and evaluating information on length-specific selectivity at older ages.

- Are there other important issues?

  As in the previous assessment, the pollock assessment models had difficulty converging on a solution in some of the retrospective peels. One possible explanation for this convergence issue is that the model may be overparameterized, because the commercial and recreational fleets are modeled separately in this assessment. The possibility of combining the two fleets into a single fleet should be explored during the next benchmark assessment.

14.1 Reviewer Comments: Pollock

Recommendation: The Panel concluded that the updated stock assessment with retrospective adjustment was acceptable as a scientific basis for management advice and agreed with the status determination that the stock is not overfished and overfishing is not occurring. The Panel accepted the current projections as a basis for the 2016-2018 overfishing limits. All data updates and changes to survey indices and model (removal of likelihood constants) were accepted by the Panel.

Alternative Assessment Approach: Not applicable

Sources of Uncertainty: The major sources of uncertainty are the selectivity of the fisheries-independent surveys and the retrospective pattern. The base model assumes dome-shaped survey selectivity and results from the model imply that a large portion of the stock biomass is unavailable to the fishery and survey. If a flat-topped selectivity is assumed, less biomass is estimated. However, stock status was insensitive to the shape of the selectivity form. The current retrospective pattern rescales the entire time series of F and SSB estimates unlike other assessments viewed in the session, and reviewers were concerned about the general accept/reject criteria for retrospective adjustment used during the meeting.

Research Needs: For the next benchmark assessment, the Panel recommended that the ASAP model be explored to find a more stable configuration. Convergence issues occurred with the retrospective peels of the model (but were fixed with changes in phase estimation) and modeling the data as a combined fleet was suggested as a possible fix. Additionally, knowledge of selectivity shape of fisheries-independent surveys could be improved with additional studies on gear selectivity. Another research recommendation included investigating alternative fitting algorithms in the model (e.g., 'robustified maximum likelihood estimation') that may perform well given highly variable survey tuning indices.

References:

Hendrickson L, Nitschke P, Linton B. 2015. 2014 Operational stock assessments for Georges Bank winter flounder, Gulf of Maine winter flounder, and pollock. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 15-01; 228 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD15-01

Northeast Fisheries Science Center. 2010. 50^{th} Northeast Regional Stock Assessment Workshop (50^{th} SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 10-17; 844 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD10-17

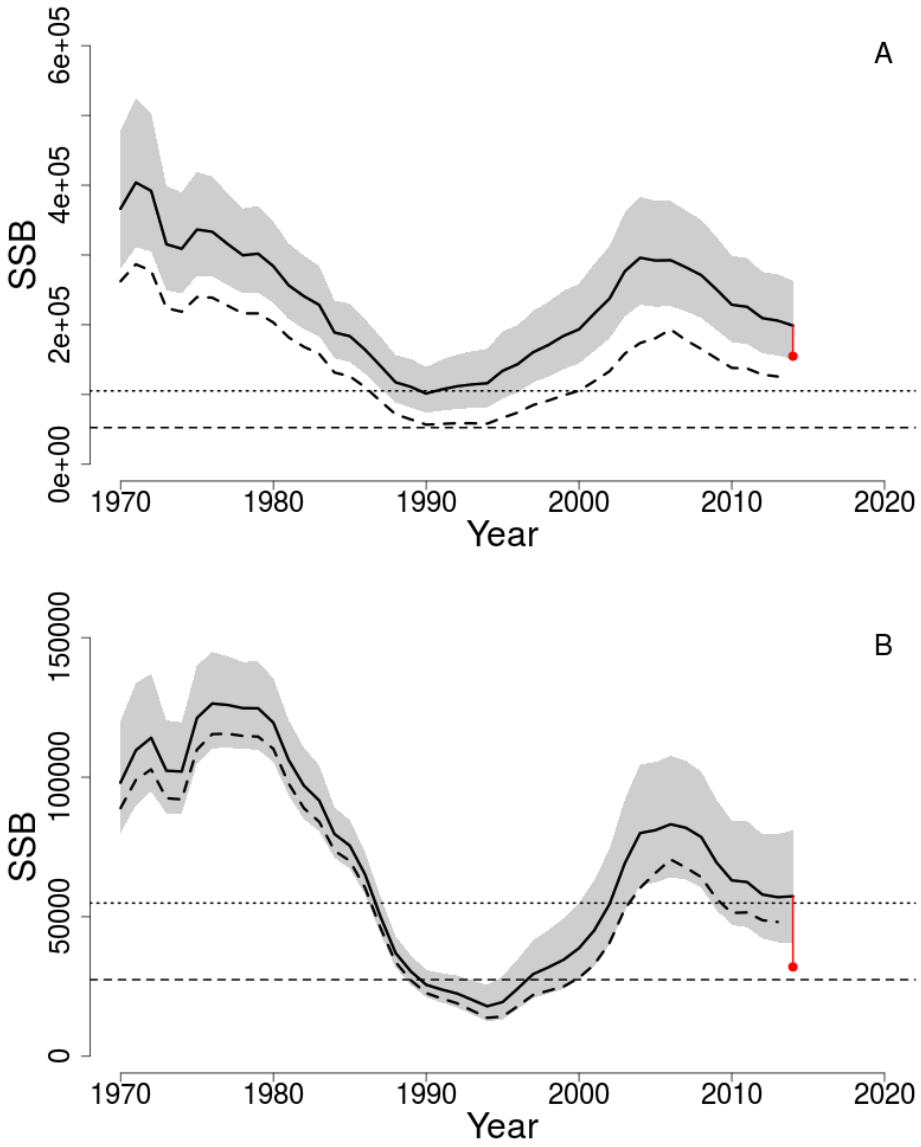

Figure 71: Estimated trends in the spawning stock biomass of pollock between 1970 and 2014 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ (0.5 * SSB_{MSY} proxy; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} proxy; horizontal dotted line) based on the 2015 assessment models base (A) and flat sel sensitivity (B). Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% lognormal confidence intervals are shown.

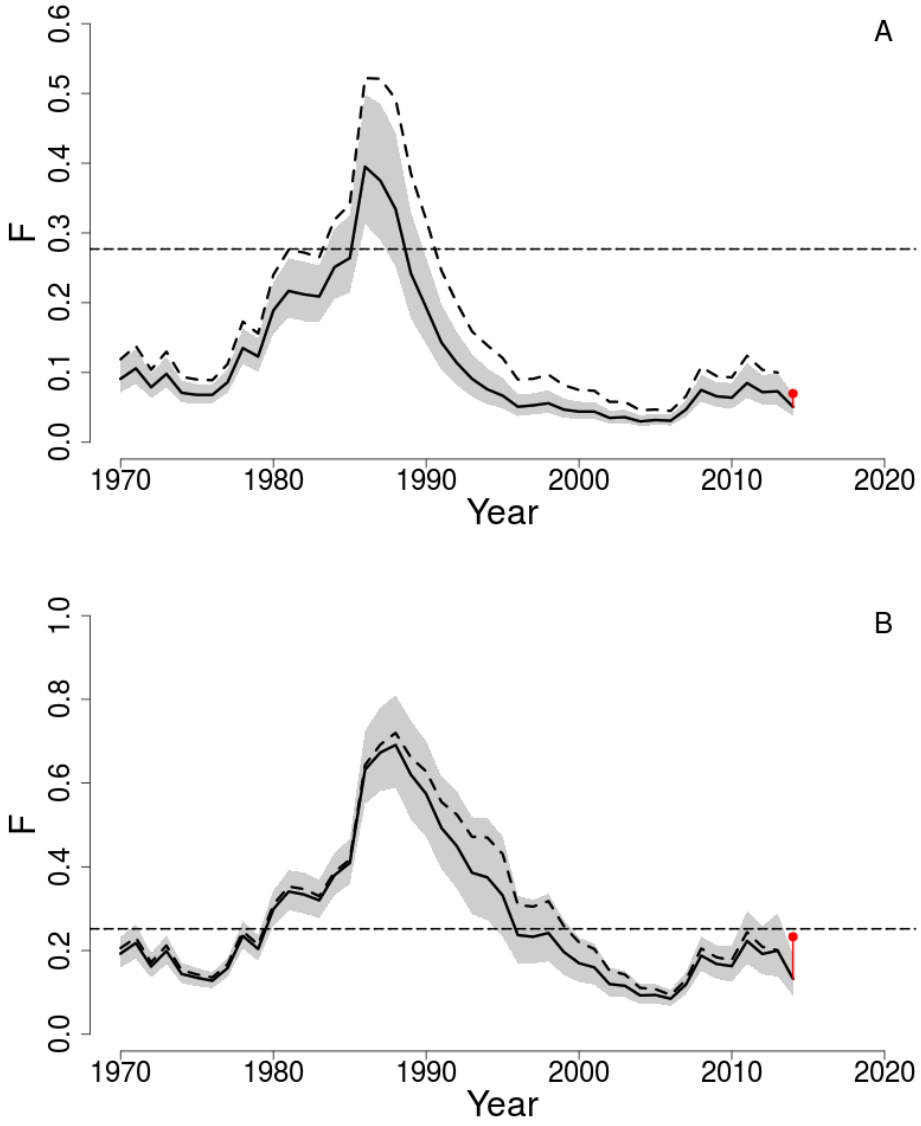

Figure 72: Estimated trends in age 5 to 7 average F (F_{AVG}) of pollock between 1970 and 2014 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} proxy; dashed line) based on the 2015 assessment models base (A) and flat sel sensitivity (B). F_{AVG} was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% lognormal confidence intervals are shown.

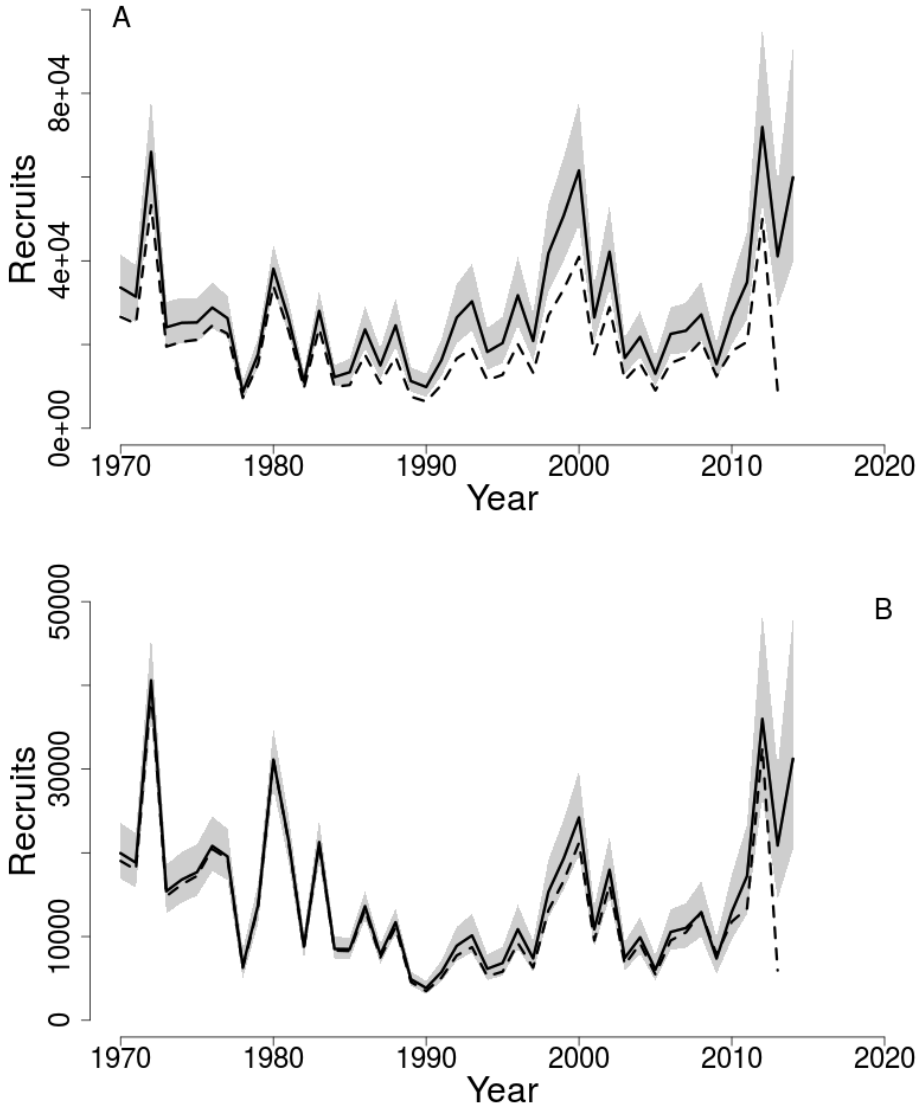

Figure 73: Estimated trends in age 1 recruitment (000s) of pollock between 1970 and 2014 from the current (solid line) and previous (dashed line) assessment for the assessment models base (A) and flat sel sensitivity (B). The approximate 90% lognormal confidence intervals are shown.

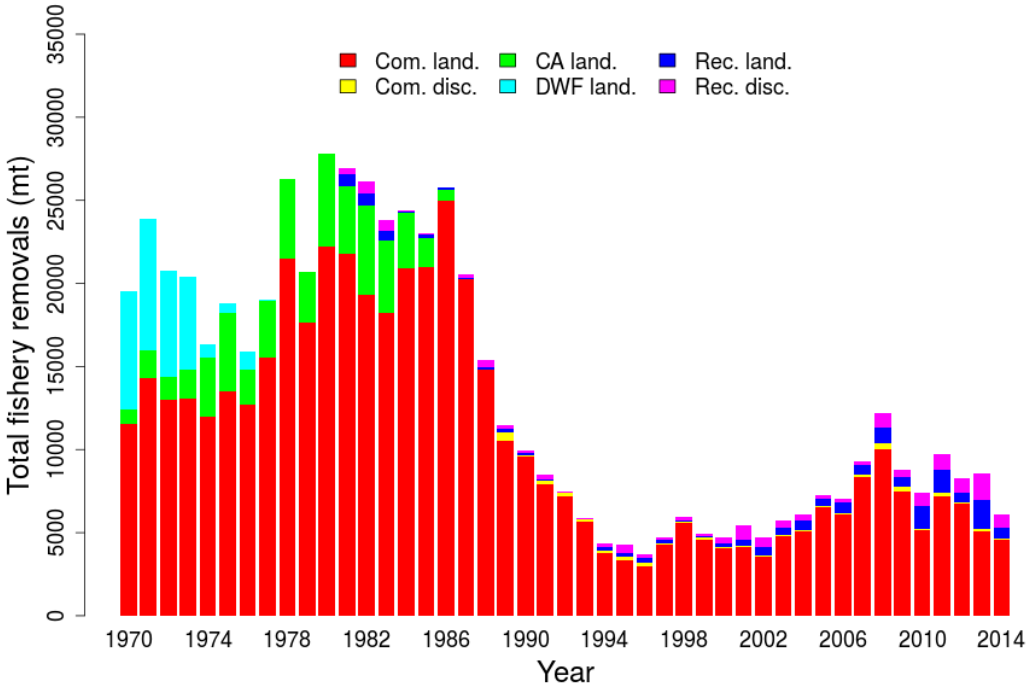

Figure 74: Total catch of pollock between 1970 and 2014 by fleet (commercial, Canadian, distant water fleet, and recreational) and disposition (landings and discards).

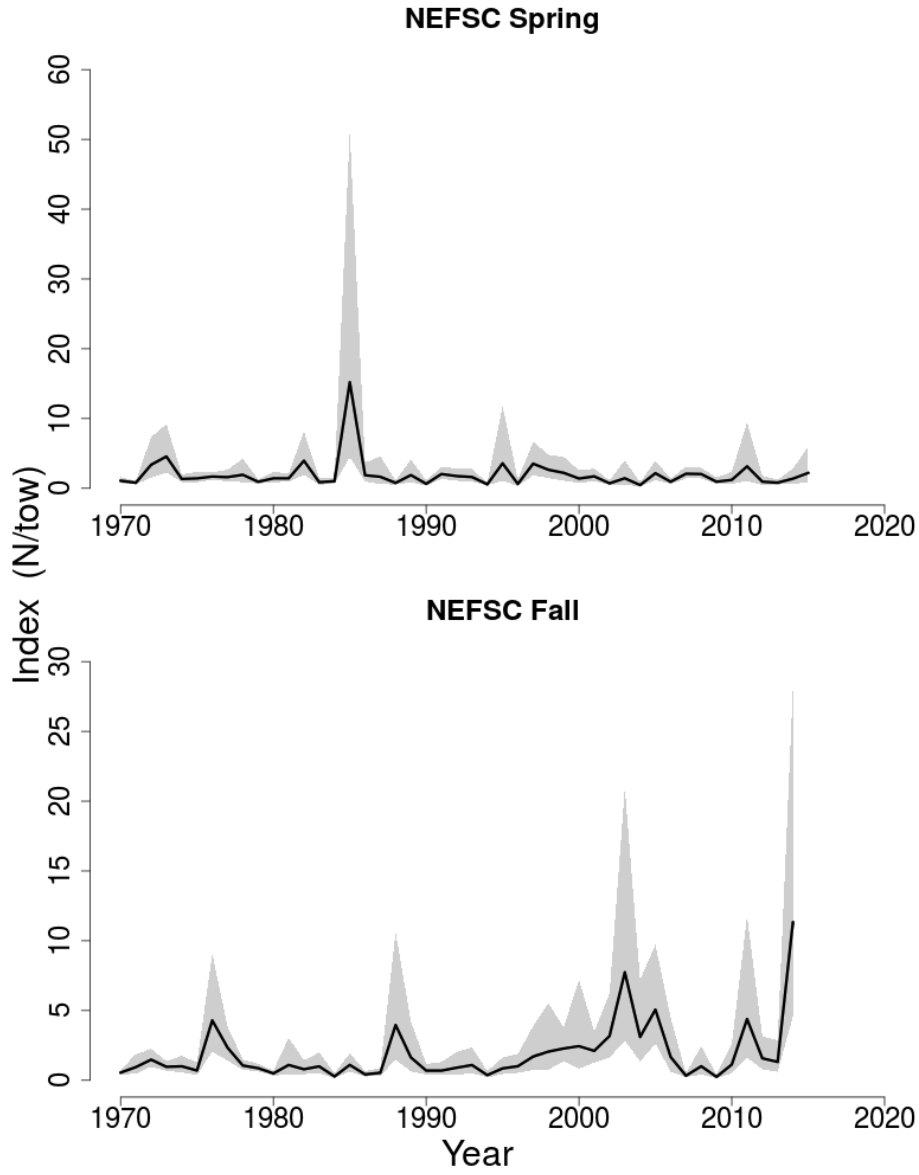

Figure 75: Indices of abundance for pollock from the Northeast Fisheries Science Center (NEFSC) spring (1970 to 2015) and fall (1970 to 2014) bottom trawl surveys. The approximate 90% lognormal confidence intervals are shown.