14 Pollock

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This assessment of the pollock (Pollachius virens) stock is an operational assessment of the existing 2015 operational assessment (NEFSC 2015). This assessment updates commercial and recreational fishery catch data, research survey indices of abundance, the ASAP analytical models, and biological reference points through 2016. Additionally, stock projections have been updated through 2020. In what follows, there are two population assessment models brought forward from the 2015 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 68-69). Retrospective adjustments were made to the model results. Retrospective adjusted spawning stock biomass (SSB) in 2016 was estimated to be 183,907 (mt) under the base model and 72,889 (mt) under the flat sel sensitivity model which is 174 and 120% (respectively) of the biomass target, an SSB_{MSY} proxy of SSB at $F_{40\%}$ (105,510 and 60,738 (mt); Figure 68). Retrospective adjusted 2016 age 5 to 7 average fishing mortality (F) was estimated to be 0.036 under the base model and 0.079 under the flat sel sensitivity model, which is 14 and 32% (respectively) of the overfishing threshold, an F_{MSY} proxy of $F_{40\%}$ (0.26 and 0.249; Figure 69).

Table 43: 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.

	2009	2010	2011	2012	2013	2014	2015	2016
			Data					
Commercial landings	7,504	5,153	7,211	6,742	5,058	4,545	3,043	2,582
Commercial discards	282	99	176	121	169	135	155	96
Recreational landings	551	1,202	1,411	544	1,404	458	324	352
Recreational discards	399	762	937	836	1,534	639	690	646
Catch for Assessment	8,735	7,217	9,736	8,243	8,164	5,777	4,212	3,676
			Model Results (base)					
Spawning Stock Biomass	232340	206689	204222	187597	184690	181430	206701	226371
F_{AVG}	0.065	0.062	0.083	0.07	0.072	0.05	0.033	0.026
Recruits $age1$	14285	23335	35624	60593	46443	103664	43328	20065
			Model Results (flat sel sensitivity)					
Spawning Stock Biomass	91786	81413	80219	73151	71337	71400	87152	102571
F_{AVG}	0.136	0.126	0.174	0.15	0.157	0.108	0.069	0.051
Recruits $age1$	7994	13105	20282	34744	26876	60273	25391	12000

Table 44: Comparison of biological reference points for pollock estimated in the 2015 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 yield per recruit analysis. F_{MSY} is reported as the age 5 to 7 average F. Recruits represent the median of the predicted recruits. Intervals shown are 5th and 95th percentiles.

	2015 base	2015 flat sel sensitivity	base	flat sel sensitivity
F_{MSY}	0.277	0.252	0.260	0.249
SSB_{MSY} (mt)	105,226	54,900	105,510 (81,832 - 145,426)	60,738 (47,146 - 84,524)
MSY (mt)	19,678	10,995	19,427 (14,312 - 29,682)	11,692 (8,701 - 17,748)
Median recruits (age 1) (000s)	25,299	12,879	22,183	13,067
Overfishing	No	No	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 2018 and 2020. Catch in 2017 has been estimated at 4,296 (mt). Recruitments were sampled from a cumulative distribution function derived from ASAP estimated age 1 recruitment between 1970 and 2014. Recruitments in 2015 and 2016 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 2016 fell outside the 90% confidence intervals of the unadjusted 2016 value under the base model (Figure 69). Retrospective adjusted SSB and age 5 to 7 average F in 2016 fell outside the 90% confidence intervals of the unadjusted 2016 values under the flat sel sensitivity model (Figures 68-69). Therefore, age-specific abundance rho values were applied to the initial numbers at age in the projections for the base model and the flat sel sensitivity model.

Table 45: 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 2018 and 2020. Catch in 2017 has been estimated at 4,296 (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*	
2017	4,296	243,345	0.025	4,296	100,184	0.056

Year	Catch (mt)	SSB (mt)	F_{AVG}	Catch (mt)	SSB (mt)	F_{AVG}
		base			*flat sel sensitivity*	
2018	51,680	286,640	0.260	23,408	121,667	0.249
2019	51,216	267,301	0.260	24,167	117,037	0.249
2020	52,269	236,653	0.260	25,974	105,719	0.249

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. Assuming that survey selectivity is flat-topped leads to lower estimates of SSB and higher estimates of F (Figures 68-69). Stock status is insensitive to the shape of the survey selectivity patterns at older ages. The strength of the 2013 year class is a source of uncertainty in the projections. The uncertainty in year class strength should decrease as additional years of data are added to the assessment.

- 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 0.284 under the base model and 0.789 under the flat sel sensitivity model in the 2015 assessment and was 0.231 and 0.407, respectively, in 2016. The 7-year Mohn's ρ, relative to F, was -0.276 under the base model and -0.43 under the flat sel sensitivity model in the 2015 assessment and was -0.278 and -0.35, respectively, in 2016. There was a major retrospective pattern for the base model because the ρ adjusted estimate of 2016 F (F_ρ=0.036) was outside the approximate 90% confidence region around F (0.018 - 0.034). There was a major retrospective pattern for the flat sel sensitivity model because the ρ adjusted estimates of 2016 SSB (SSB_ρ=72,889) and 2016 F (F_ρ=0.079) were outside the approximate 90% confidence region around SSB (76,914 - 128,228 (mt)) and F (0.037 - 0.066). A retrospective adjustment was made for both the determination of stock status and for projections of catch in 2018. The base model retrospective adjustment changed the 2016 SSB from 226,371 to 183,907 and the 2016 F_{AVG} from 0.026 to 0.036. The flat sel sensitivity model retrospective adjustment changed the 2016 SSB from 102,571 to 72,889 and the 2016 F_{AVG} from 0.051 to 0.079.

- Based on this stock assessment, are population projections well determined or uncertain? If this stock is in a rebuilding plan, how do the projections compare to the rebuilding schedule?

  Population projections for pollock appear to be reasonably well determined for both the base model and the flat sel sensitivity model. The stock is not in a rebuilding plan.

- 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 change was made to the pollock assessment as part of this update. A multinomial logistic model was used to estimate proportions at age for length bins where no age samples were available (Gerritsen et al. 2006) in survey age-length keys. Survey age-length key holes were filled manually based on the expert judgment of the assessment analyst in previous assessments. There was little difference in the survey indices at age produced by the multinomial filling method compared to the indices at age produced by the manual filling method. The multinomial filling method is part of an effort by Northeast Fisheries Science Center (NEFSC) staff to standardize construction of survey indices.

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

  Stock status based on the base and flat sel sensitivity models has not changed since the previous assessment.

- Provide qualitative statements describing the condition of the stock that relate to stock status.

  Total removals of pollock have declined since 2008. The spring survey index has increased since 2013, while the fall survey index has decreased since 2014. Survey data suggests the exisitence of a relatively strong 2014 year class, which has yet to enter the commercial fishery. Survey data suggests that older fish have begun to reappear in the stock since the 1990s.

- 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

Assessment Recommendation:

The panel concluded that the operational assessment with adjustments for retrospective bias was acceptable as a scientific basis for management advice using the approved base model with dome-shaped selectivity on all fleets and surveys.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this assessment, the panel supports the conclusion that the pollock stock is not overfished and overfishing is not occurring. Total removals of pollock have declined since 2008. The spring survey index has increased since 2013, while the fall survey index has decreased since 2014. Survey data suggests the existence of a relatively strong 2013 year class, which has yet to enter the commercial fishery. Survey data suggests that older fish have begun to reappear in the stock since the 1990s.

Key Sources of Uncertainty:

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. Assuming that survey selectivity is flat-topped leads to lower estimates of spawning stock biomass and higher estimates of F. For that reason, it is relatively risk-prone to manage assuming dome-shaped selectivity, if in fact, flat-topped selectivity is occurring. Stock status is insensitive to the shape of the survey selectivity patterns at older ages. There are convergence issues in conducting the retrospective analysis; perhaps the model is overparameterized due to separate commercial and recreational fleets. Also, the actual strength of 2013 year class is yet to be realized in the fishery and therefore remains a source of uncertainty. Due to the risk-prone nature of managing under the assumption of dome-shaped selectivity, the panel recommends a decision table be used to communicate the results of the base assessment model and the sensitivity model.

Research Needs:

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. Given the convergence issues, alternative model configurations should be explored, such as combining the two fleets into a single fleet. Consider exploring the age composition of the survey and its ability to track cohorts relative to the strong cohorts present in the fishery compositional data as this could also be a potential source of the convergence issues.

References:

Gerritsen, H.D., D. McGrath, and C. Lordan. 2006. A simple method for comparing age-length keys reveals significant regional differences within a single stock of haddock (*Melanogrammus aeglefinus*). ICES J Mar Sci 63: 1096-1100.

Northeast Fisheries Science Center. 2010. 50th Northeast Regional Stock Assessment Workshop (50th 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

Northeast Fisheries Science Center. 2015. 2014 Operational Assessment of 20 Northeast Groundfish Stocks, Updated Through 2014. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 15-24; 251 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD15-24

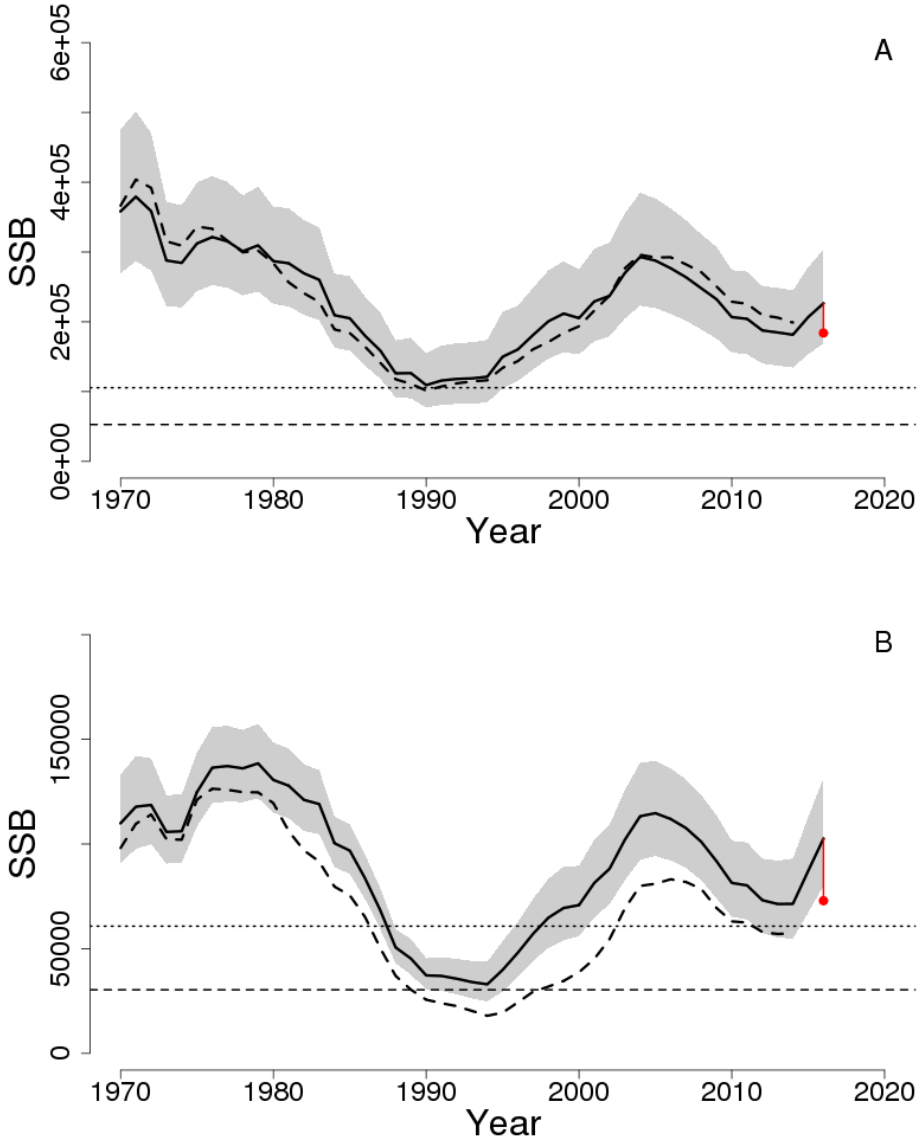

Figure 68: Estimated trends in the spawning stock biomass of pollock between 1970 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ (0.5 * SSB_{MSY} proxy; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} proxy; horizontal dotted line) based on the 2017 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.

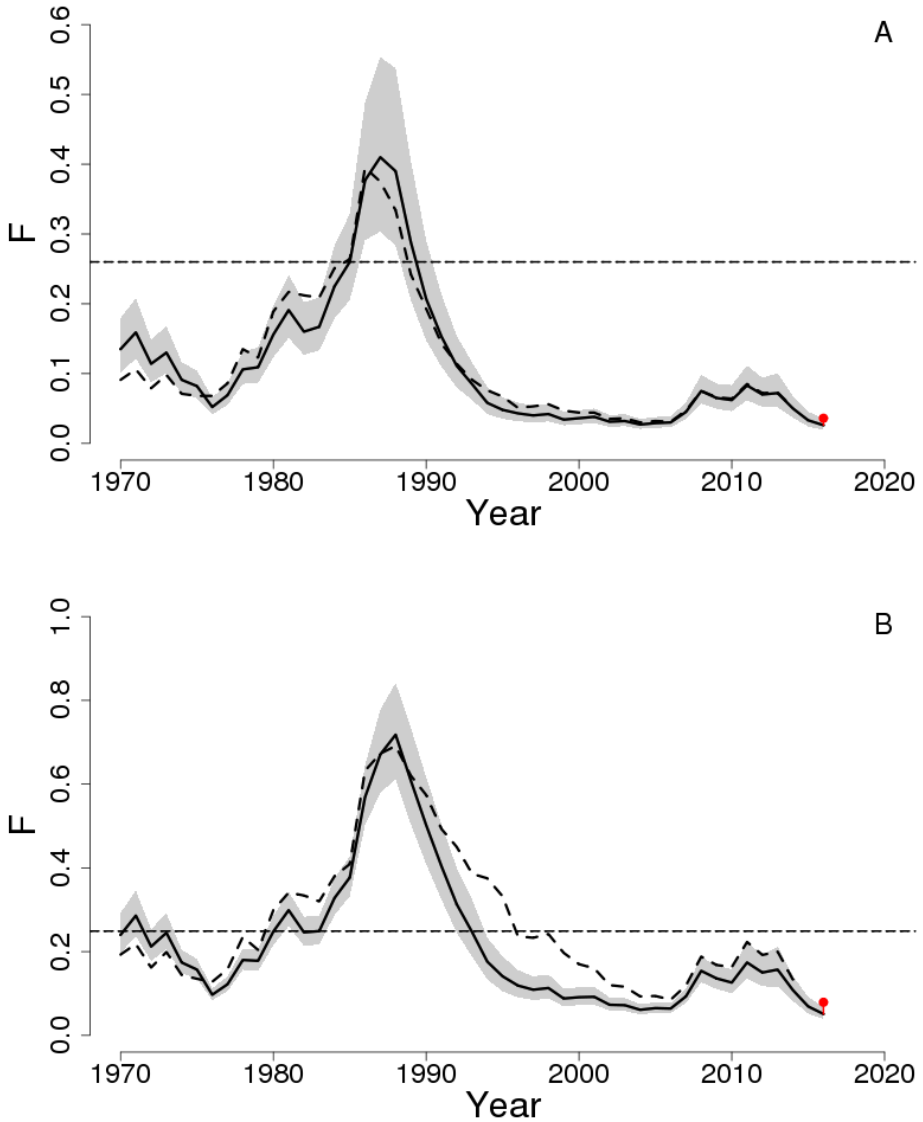

Figure 69: Estimated trends in age 5 to 7 average F (F_{AVG}) of pollock between 1970 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} proxy; dashed line) based on the 2017 assessment models base (A) and flat sel sensitivity (B). F_{AVG} was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% lognormal confidence intervals are shown.

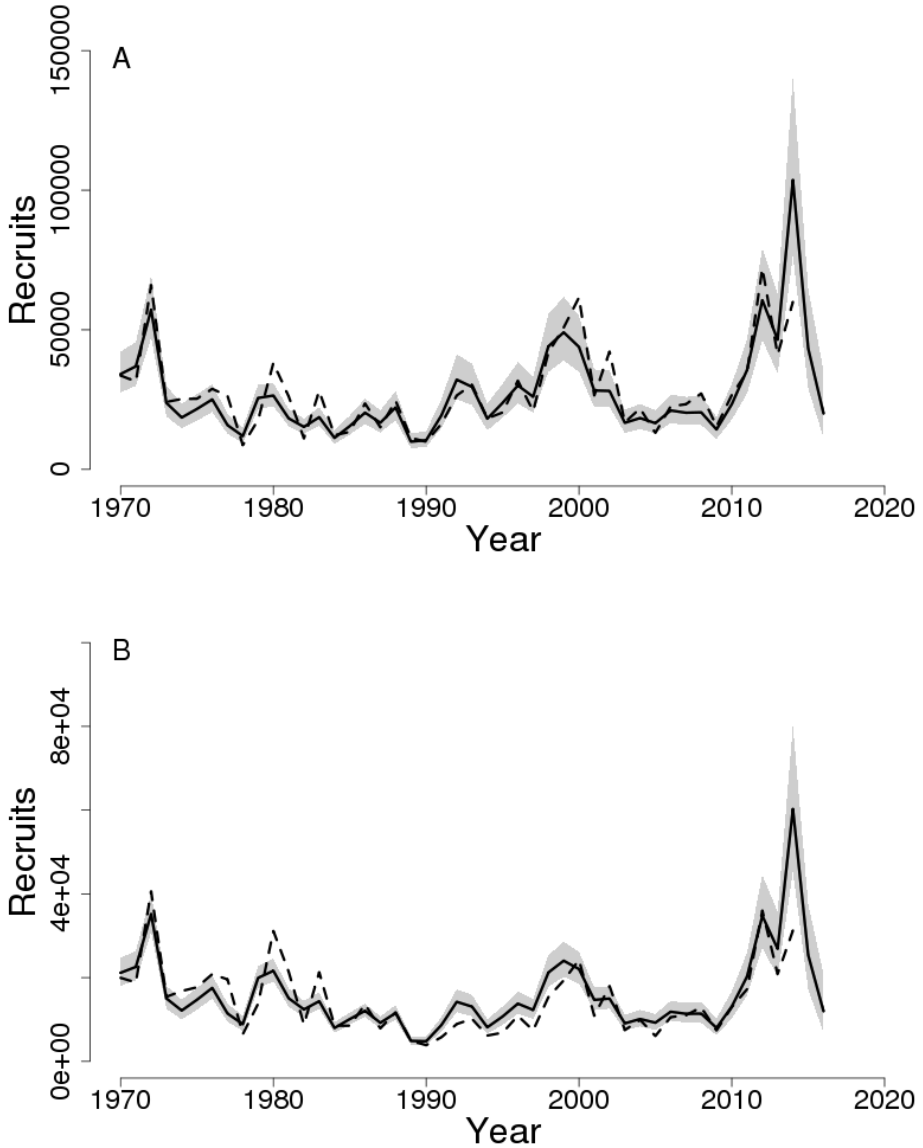

Figure 70: Estimated trends in age 1 recruitment (000s) of pollock between 1970 and 2016 from the current (solid line) and previous (dashed line) assessment for the assessment models base (A) and flat sel sensitivity (B). The approximate 90% lognormal confidence intervals are shown.

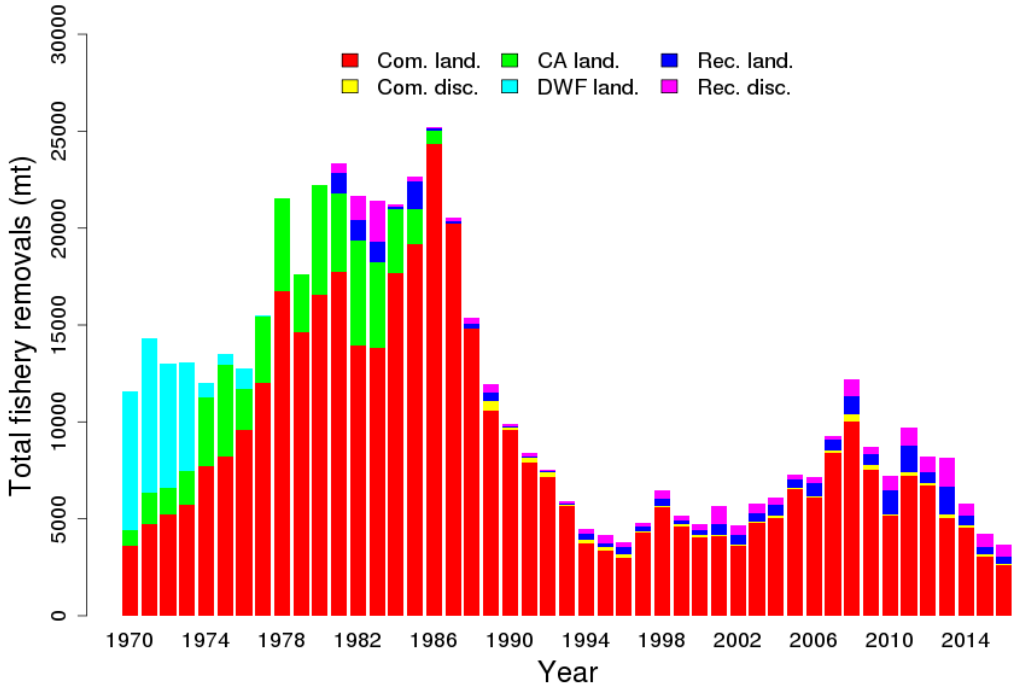

Figure 71: Total catch of pollock between 1970 and 2016 by fleet (commercial, Canadian, distant water fleet, and recreational) and disposition (landings and discards).

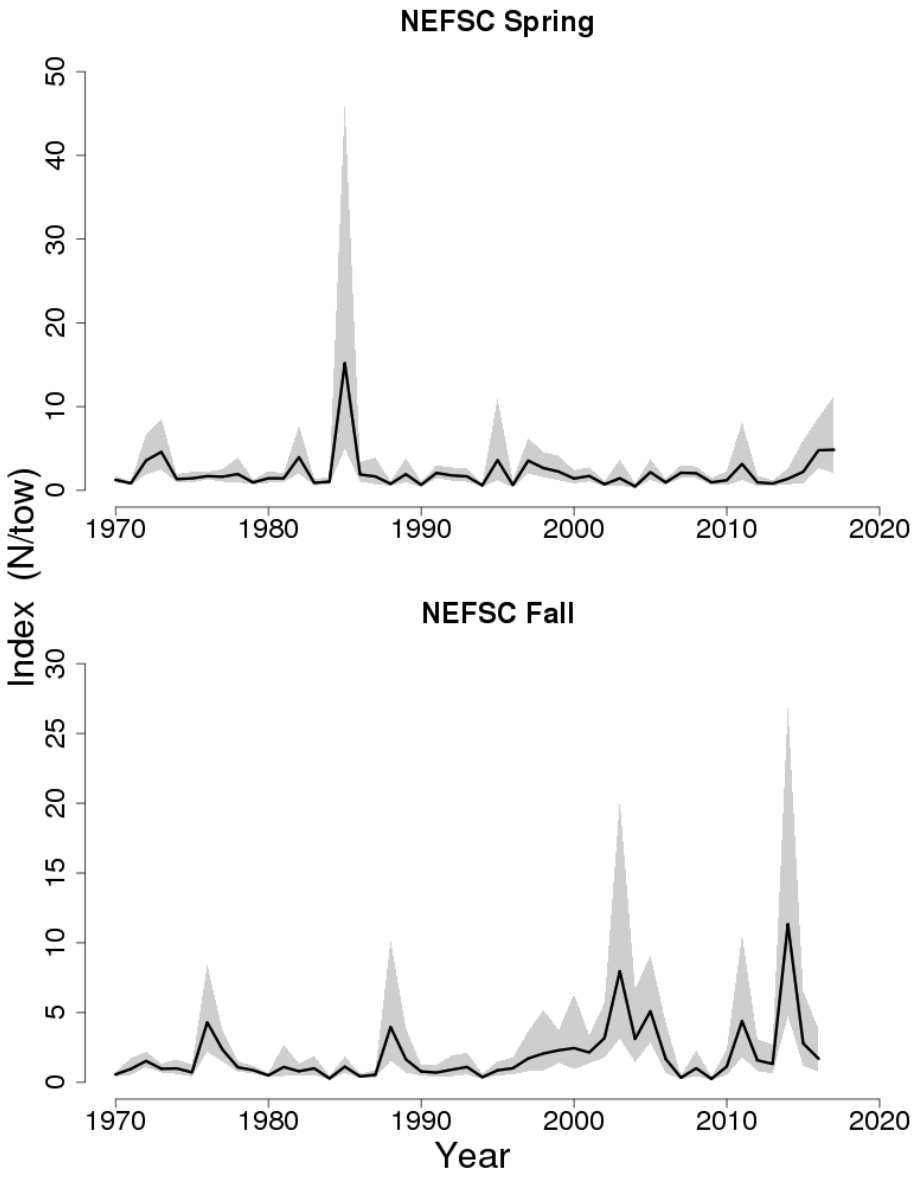

Figure 72: Indices of abundance for pollock from the Northeast Fisheries Science Center (NEFSC) spring (1970 to 2017) and fall (1970 to 2016) bottom trawl surveys. The approximate 90% lognormal confidence intervals are shown.