Catch Rates of Yellowtail Flounder in the New England Trawl Fishery

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Summary – Commercial landings and fishing effort statistics from fishermen's logbooks were used to develop standardized time series of yellowtail flounder landings per unit effort (LPUE) from trawl fisheries in the Cape Cod-Gulf of Maine (CCGOM), Georges Bank (GB) and southern New England-Mid Atlantic (SNEMA) stock areas. The standardized LPUE series, 1996-2019, are generally correlated with survey biomass indices, but there were significant and poorly estimated interaction effects, and recent low catch limits have caused some avoidance behavior.

Introduction

Many of the New England groundfish stock assessments traditionally included fishery catch rates as indices of abundance in stock assessment models (NEFMC 2020). Lux (1964) developed LPUE indices (landings per day fishing) for yellowtail from all three stock areas using port interviews of trips with yellowtail contributing at least 50% of the total catch, standardized to 26-50 ton vessels. O'Brien & Mayo (1988) tested patterns of yellowtail LPUE by vessel tonnage, fishing area and depth and developed a standardized LPUE with tonnage class effects. Considering standardized LPUE for yellowtail stock assessment was discontinued in the late 1990s because of changes to the management system and the fishery monitoring system, from port interviews to fishermen's logbooks (NEFSC 1996, 1997). The objective of this study is to summarize patterns of LPUE for New England yellowtail stocks, for comparison with survey indices and to characterize trends in the fishery.

Methods

Catch rate series were developed for the New England trawl fishery using 1996-2019 logbook data (NEFSC 1996, 1997). Data from 1994-1995 were excluded because of concerns about data quality in those first years after the transition from port interviews to logbooks. The logbook data is assumed to be a census of landings and effort, but the resolution of fishing effort and area fished is relatively imprecise. Large-mesh bottom trawl trips were selected because they catch most yellowtail in the fishery (NEFSC 2012). Tonnage classes were defined as 1: <50t; 2: 51-100t; 3: 101-150t; 4: >150t. Fishing effort was derived as trawl tow duration (hr), and LPUE was derived as lb/hr.

A series of Generalized Linear models (GLMs) were developed for Ln(LPUE) with calendar year, quarter-year, statistical area, and tonnage class main effects and first order interaction effects with year (Gavaris 1980). GLMs were modeled using the R (version 4.0.3) glm function (Venables and Ripley 2002). Models were compared using Akaike's information criterion (AIC). A standardized LPUE index was derived from re-transformed year coefficients. Evaluation of stock trends was tested using Log correlation with available survey biomass indices (NEFSC 2022, TRAC 2022).

Results

Trawl LPUE of yellowtail flounder was relatively low in recent years for all three stock areas (Figure 1). Distribution of LPUE was skewed, but Ln(LPUE) was normally distributed for CCGOM and approximately so for GB and SNE (Figures 1 and 2). Optimal models (lowest AIC and greatest % deviance explained) had main effects of calendar year, vessel tonnage class, quarter-year, statistical area, and first order interaction effects for all three stock areas (Table 1). However, full models had highly uncertain estimates of some interaction coefficients, so results from models with main effects amnd no interactions are presented. Deviance explained by models with interactions was 24% for the CCGOM stock, 43% for the GB stock, and 33% for the SNEMA stock, and significantly less for the main effects models (19% for CCGOM, 36% for GB, 25% for SNEMA). Fishing area had the greatest effect on LPUE for all three stocks. Residual analyses suggest relatively good fit of the CCGOM model, but moderate departures from the lognormal assumption for GB and SNEMA data (Figure 3-5).

Trends in standardized LPUE varied among stocks (Tables 2-4, Figure 6), but are generally consistent with survey trends (Table 5, Figure 6). LPUE was relatively low for the most recent year for all stocks LPUE had three peaks in CCGOM in the early 2000, 2011 and 2016, which are also indicated by surveys. LPUE in GB peaked in 2005, then gradually decreased to extreme lows since 2013, similar to survey trends. LPUE in SNEMA peaked in 2012 then decreased sharply to record low in the last decade, but the decrease in LPUE was a few years later than the decrease in survey indices.

Discussion

Although general trends in standardized LPUE are consistent with survey and assessment trends, there were significant and poorly estimated interaction effects, and recent low catch limits have caused some avoidance behavior. Spatiotemporal analysis of finer-scale fishery data (e.g., at-sea observers, study fleet) may be able to account for spatial and temporal interactions better than conventional GLMs (e.g., Grüss et al. 2019).

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Table 1. Standardization models for yellowtail flounder LPUE by stock area, with main effects of year (Y), quarter-year (Q), area (A), tonnage class (T) and interactions (x) with deltaAIC and % deviance explained for each model. The saturated model has all first order interactions.

Cape Cod-Gulf of Maine

Model	AIC	deltaAIC	%deviance
Y	258517	14207	5%
Y+Q	257452	13142	6%
Y+Q+YxQ	256018	11708	8%
Y+A	251587	7277	14%
Y+A+YxA	250299	5989	16%
Y+T	253873	9563	11%
Y+T+YxT	252237	7927	14%
Y+Q+A	249988	5678	16%
Y+Q+T	252282	7972	13%
Y+A+T	249860	5550	17%
Y+Q+A+T	247886	3576	19%
Y+Q+A+T+YxT	246333	2023	21%
Y+Q+A+T+YxA	246452	2142	21%
Y+Q+A+T+YxQ	246532	2222	21%
Y+Q+A+T+ALLx	244310	0	24%

Georges Bank

Model	AIC	deltaAIC	%deviance
Y	38362	2573	21%
Y+Q	38132	2343	23%
Y+Q+YxQ	37816	2027	27%
Y+A	36647	858	34%
Y+A+YxA	36271	482	38%
Y+T	38179	2390	23%
Y+T+YxT	38128	2339	24%
Y+Q+A	36565	776	35%
Y+Q+T	37915	2126	25%
Y+A+T	36566	777	35%
Y+Q+A+T	36374	585	36%
Y+Q+A+T+YxT	36321	532	38%
Y+Q+A+T+YxA	35972	183	40%
Y+Q+A+T+YxQ	36190	401	39%
Y+Q+A+T+ALLx	35789	0	43%

Southern New England-Mid Atlantic

Model	AIC	deltaAIC	%deviance
Y	87837	4051	19%
Y+Q	87120	3334	22%
Y+Q+YxQ	86211	2425	25%
Y+A	87051	3265	22%
Y+A+YxA	85878	2092	27%
Y+T	87376	3590	21%
Y+T+YxT	87186	3400	22%
Y+Q+A	86250	2464	25%
Y+Q+T	86519	2733	24%
Y+A+T	86910	3124	22%
Y+Q+A+T	85995	2209	25%
Y+Q+A+T+YxT	85775	1989	26%
Y+Q+A+T+YxA	84787	1001	30%
Y+Q+A+T+YxQ	84985	1199	29%
Y+Q+A+T+ALLx	83786	0	33%

Table 2. GLM coefficients for LPUE standardization of CCGOM yellowtail flounder.

	Estimate	SE	t	P	Index
Intercept	0.89	0.59	1.51	0.13	2.44
1997	-0.07	0.03	-2.48	0.01	2.28
1998	-0.10	0.03	-3.55	0.00	2.22
1999	0.07	0.03	2.43	0.02	2.63
2000	0.85	0.03	30.38	0.00	5.69
2001	0.77	0.03	22.31	0.00	5.27
2002	0.85	0.04	21.17	0.00	5.71
2003	0.55	0.04	12.80	0.00	4.22
2004	0.09	0.04	2.14	0.03	2.68
2005	0.14	0.04	3.24	0.00	2.80
2006	0.19	0.04	4.20	0.00	2.94
2007	0.52	0.04	11.86	0.00	4.13
2008	0.73	0.04	16.29	0.00	5.07
2009	0.68	0.05	14.27	0.00	4.82
2010	0.98	0.06	17.53	0.00	6.52
2011	0.24	0.05	4.60	0.00	3.11
2012	0.58	0.05	12.60	0.00	4.36
2013	0.54	0.05	9.93	0.00	4.18
2014	0.72	0.05	13.77	0.00	5.04
2015	0.75	0.05	13.79	0.00	5.16
2016	1.04	0.06	18.35	0.00	6.93
2017	0.86	0.05	16.52	0.00	5.79
2018	0.04	0.05	0.97	0.33	2.55
2019	-0.32	0.05	-6.74	0.00	1.78
Q2	0.27	0.02	13.77	0.00	
Q3	-0.49	0.02	-24.21	0.00	
Q4	-0.17	0.02	-8.34	0.00	
512	1.40	0.62	2.24	0.02	
512	0.92	0.59	1.56	0.12	
512	2.15	0.59	3.64	0.00	
512	1.33	0.60	2.23	0.03	
521	2.63	0.59	4.46	0.00	
TC2	0.72	0.02	36.72	0.00	
TC3	1.03	0.04	28.06	0.00	
TC4	1.32	0.05	27.79	0.00	

Table 3. GLM coefficients for LPUE standardization of GB yellowtail flounder.

	Estimate	SE	t	P	Index
Intercept	2.42	0.28	8.49	0.00	11.24
1997	0.28	0.09	3.00	0.00	14.87
1998	0.75	0.09	8.34	0.00	23.85
1999	0.92	0.09	10.09	0.00	28.13
2000	1.06	0.09	12.30	0.00	32.55
2001	1.25	0.09	13.30	0.00	39.19
2002	0.79	0.11	7.08	0.00	24.71
2003	0.87	0.11	7.75	0.00	26.78
2004	1.45	0.11	13.32	0.00	47.73
2005	0.61	0.11	5.47	0.00	20.73
2006	-0.09	0.11	-0.78	0.44	10.29
2007	-0.19	0.11	-1.67	0.10	9.29
2008	0.78	0.12	6.34	0.00	24.64
2009	0.18	0.11	1.67	0.09	13.44
2010	-0.21	0.12	-1.75	0.08	9.09
2011	0.22	0.12	1.82	0.07	14.07
2012	-0.79	0.12	-6.32	0.00	5.11
2013	-1.55	0.15	-10.39	0.00	2.38
2014	-1.66	0.14	-11.59	0.00	2.13
2015	-1.41	0.14	-10.29	0.00	2.75
2016	-2.21	0.16	-13.89	0.00	1.24
2017	-2.11	0.18	-11.53	0.00	1.36
2018	-1.65	0.20	-8.16	0.00	2.15
2019	-2.41	0.26	-9.42	0.00	1.01
Q2	-0.02	0.05	-0.29	0.77	
Q3	-0.12	0.06	-1.86	0.06	
Q4	0.13	0.06	2.02	0.04	
525	1.81	0.05	39.18	0.00	
561	0.45	0.06	7.38	0.00	
562	1.37	0.06	22.70	0.00	
TC2	2.63	0.28	9.47	0.00	
TC3	2.28	0.27	8.32	0.00	
TC4	1.94	0.28	7.06	0.00	

Table 4. GLM coefficients for LPUE standardization of SNEMA yellowtail flounder.

	Estimate	SE	t	P	Index
Intercept	5.64	0.07	80.16	0.00	282.09
1997	0.19	0.05	4.07	0.00	342.19
1998	-0.10	0.05	-2.09	0.04	254.25
1999	0.30	0.05	6.34	0.00	380.22
2000	0.32	0.05	6.58	0.00	388.34
2001	0.35	0.05	7.02	0.00	400.40
2002	0.08	0.06	1.38	0.17	306.63
2003	-0.06	0.07	-0.86	0.39	265.76
2004	-0.34	0.08	-4.43	0.00	200.47
2005	-0.53	0.09	-6.10	0.00	166.75
2006	-0.59	0.07	-8.56	0.00	156.99
2007	-0.30	0.06	-4.88	0.00	209.12
2008	-0.09	0.06	-1.61	0.11	256.79
2009	0.34	0.07	5.10	0.00	395.40
2010	0.16	0.08	2.05	0.04	329.83
2011	0.51	0.08	6.45	0.00	468.28
2012	0.90	0.08	11.66	0.00	690.75
2013	0.62	0.06	10.06	0.00	525.59
2014	0.64	0.06	10.11	0.00	537.25
2015	0.11	0.06	1.96	0.05	315.53
2016	-0.41	0.06	-6.61	0.00	186.84
2017	-1.58	0.06	-24.43	0.00	57.95
2018	-2.51	0.07	-35.65	0.00	22.83
2019	-3.45	0.09	-37.89	0.00	8.97
Q2	-0.54	0.02	-21.51	0.00	165.14
Q3	-0.44	0.03	-12.52	0.00	182.54
Q4	-0.50	0.02	-20.41	0.00	170.75
537	-0.59	0.06	-10.05	0.00	155.71
539	-1.04	0.06	-17.19	0.00	100.16
612	-0.60	0.07	-8.33	0.00	155.56
613	-0.94	0.06	-15.17	0.00	110.46
614	-3.22	1.44	-2.23	0.03	11.24
615	-1.18	0.22	-5.25	0.00	86.83
616	-1.35	0.15	-9.00	0.00	73.04
621	-1.16	0.65	-1.79	0.07	88.50
622	-0.95	0.83	-1.14	0.25	108.78
623	-1.67	0.42	-3.96	0.00	53.34
TC2	0.27	0.02	12.88	0.00	371.15
TC3	0.34	0.03	10.56	0.00	396.41
TC4	0.36	0.05	6.80	0.00	404.50

Table 5. Log correlations between yellowtail flounder LPUE and survey biomass indices.

CCGOM

	LPUE	NEFSC spring	NEFSC fall	MADMF spring	MADMF fall	MENH spring	MENH fall
LPUE	1.00						
NEFSC spring	0.67	1.00					
NEFSC fall	0.23	0.49	1.00				
MADMF spring	0.58	0.41	0.22	1.00			
MADMF fall	0.13	-0.17	0.01	0.33	1.00		
MENH spring	0.49	0.28	0.09	0.04	-0.63	1.00	
MENH fall	0.02	0.20	0.16	0.15	-0.09	0.42	1.00

GB

	LPUE	NEFSC spring	NEFSC fall	Canada
LPUE	1.00			
NEFSC spring	0.76	1.00		
NEFSC fall	0.90	0.79	1.00	
Canada	0.86	0.81	0.89	1.00

SNE-MA

	LPUE	NEFSC spring	NEFSC fall	Winter Survey
LPUE	1.00			
Spring Survey	0.74	1.00		
Fall Survey	0.54	0.75	1.00	
Winter Survey	0.25	0.76	0.56	1.00

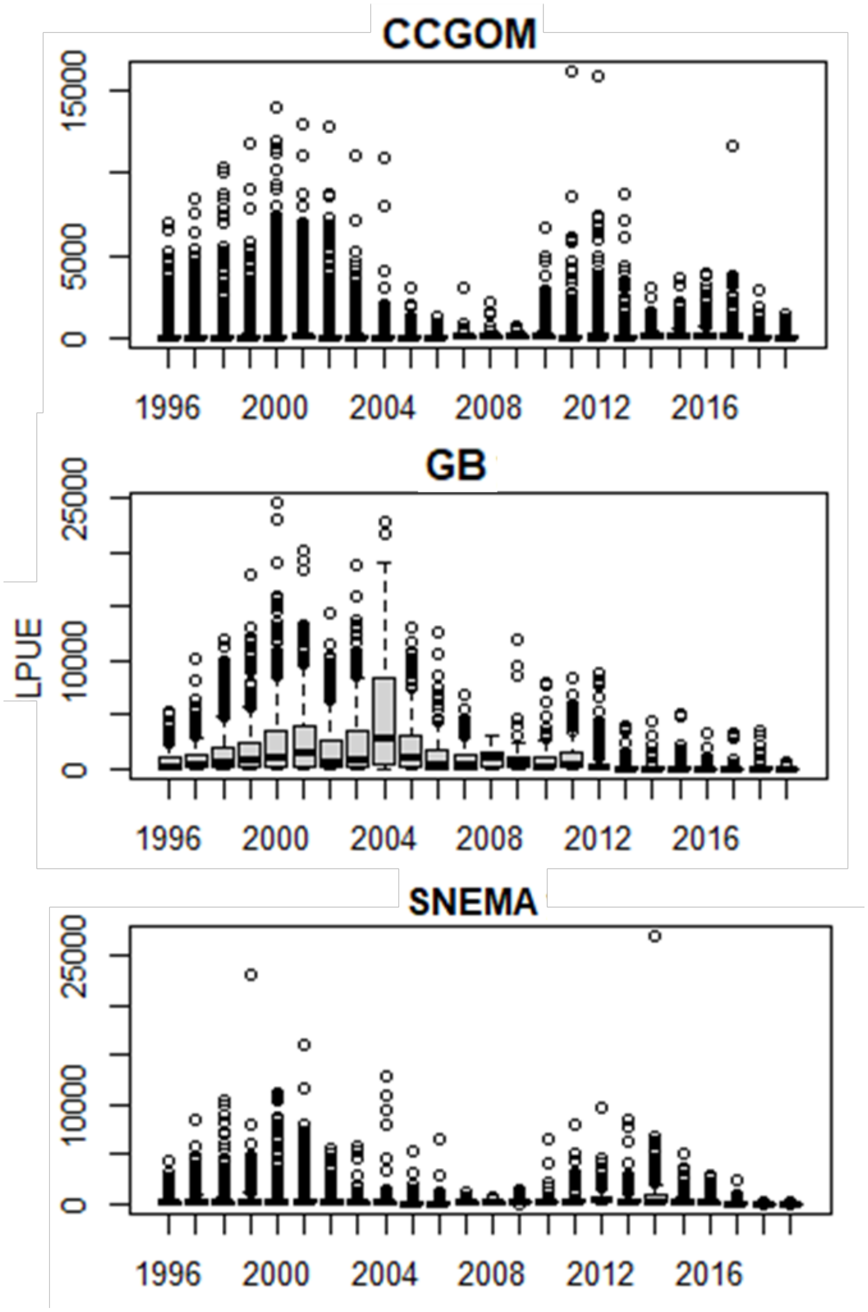


Figure 1. Yellowtail flounder trawl LPUE by stock and year.

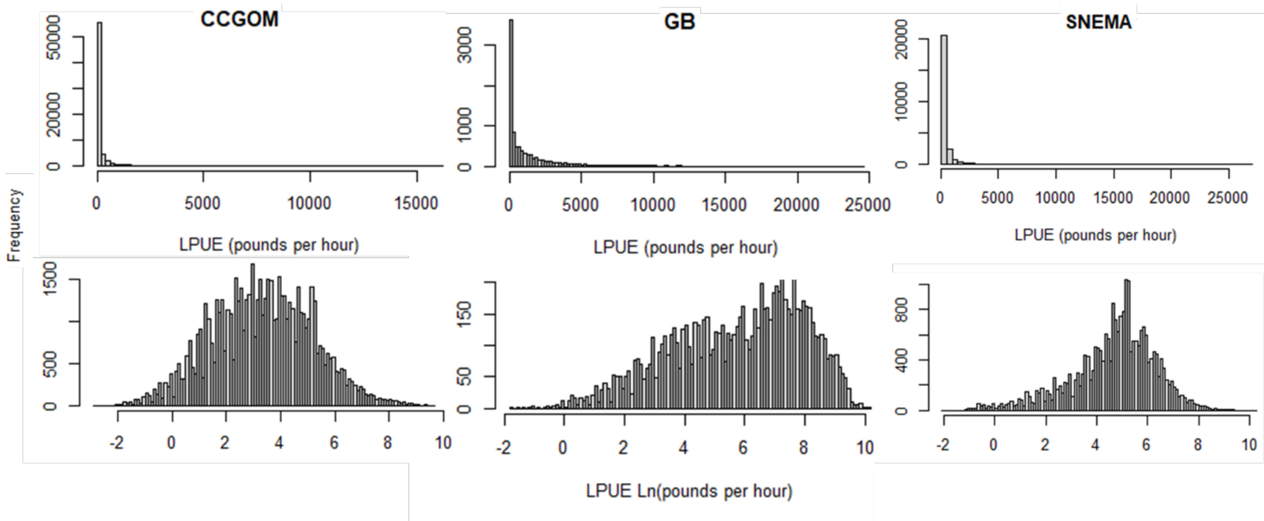


Figure 2. Distribution of yellowtail flounder trawl LPUE and Ln(LPUE) by stock.

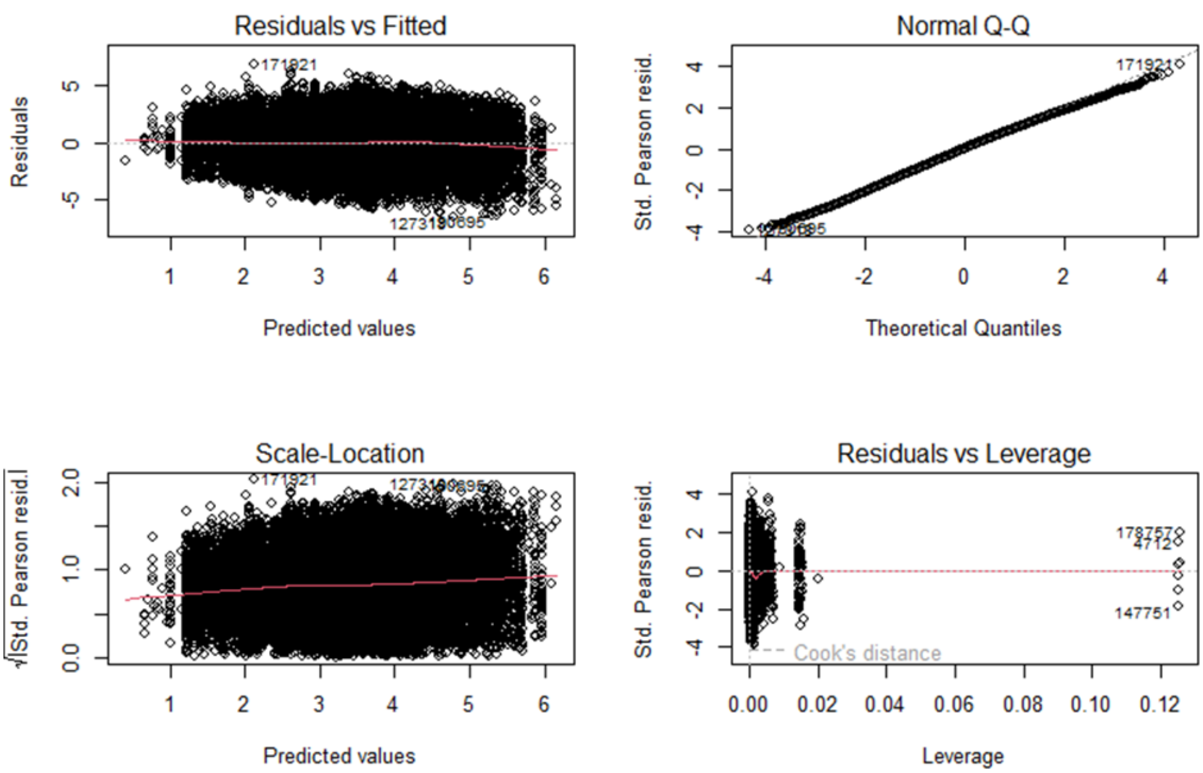


Figure 3. Residual analysis of LPUE standardization for CC-GOM yellowtail flounder.

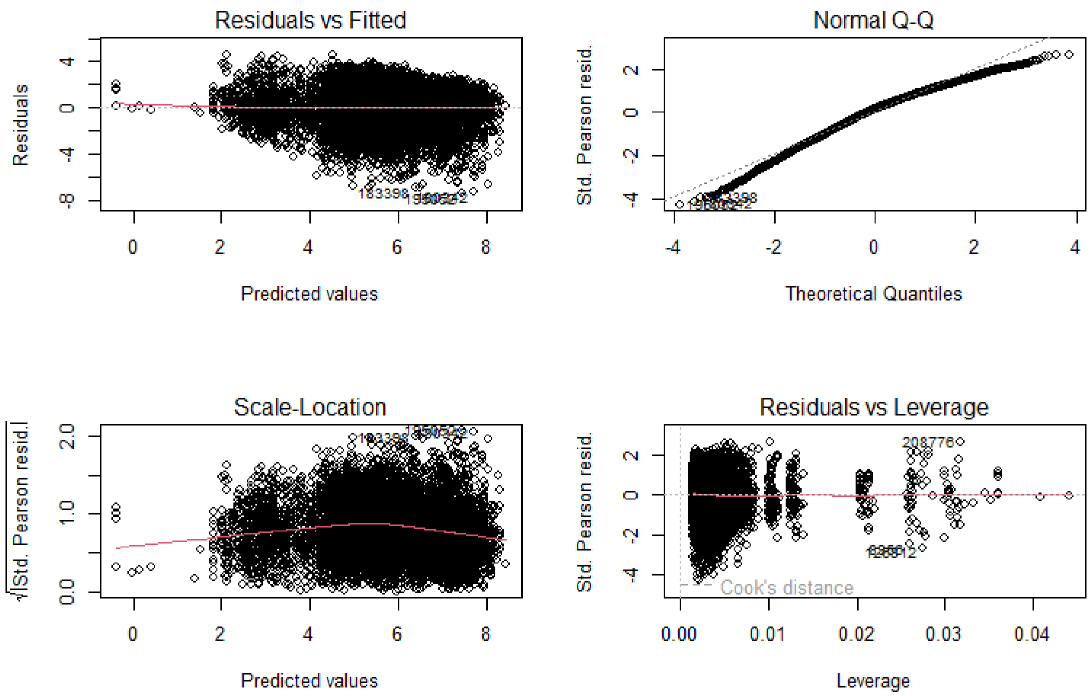


Figure 4. Residual analysis of LPUE standardization for CC-GOM yellowtail flounder.

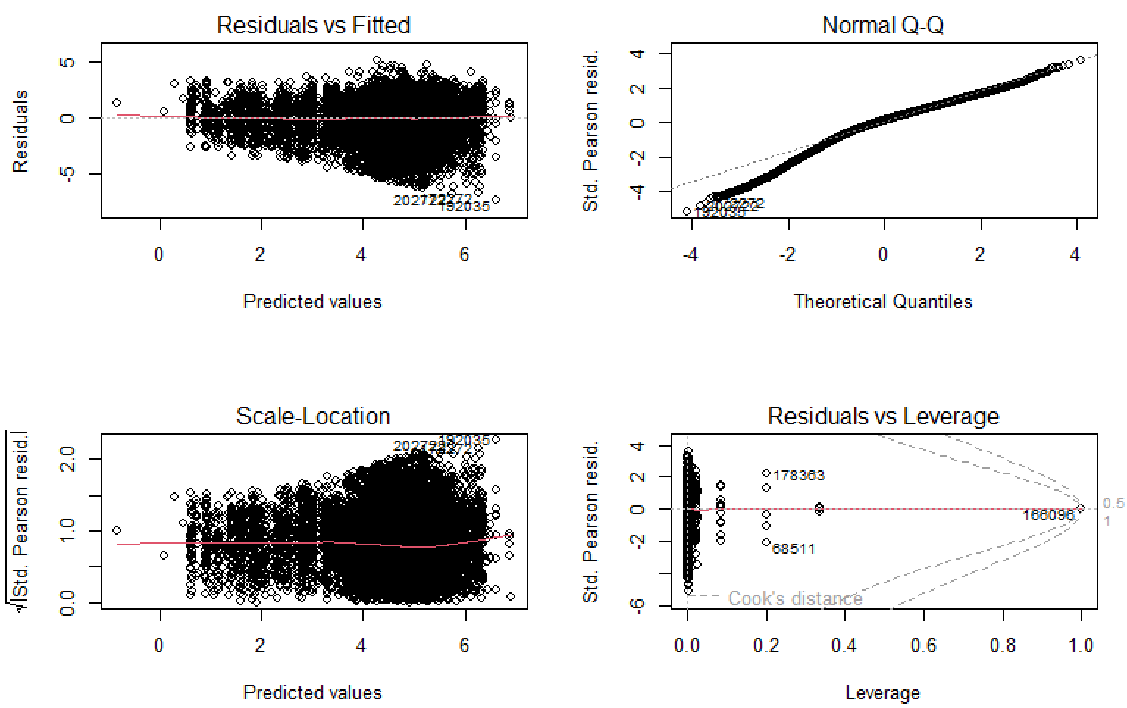
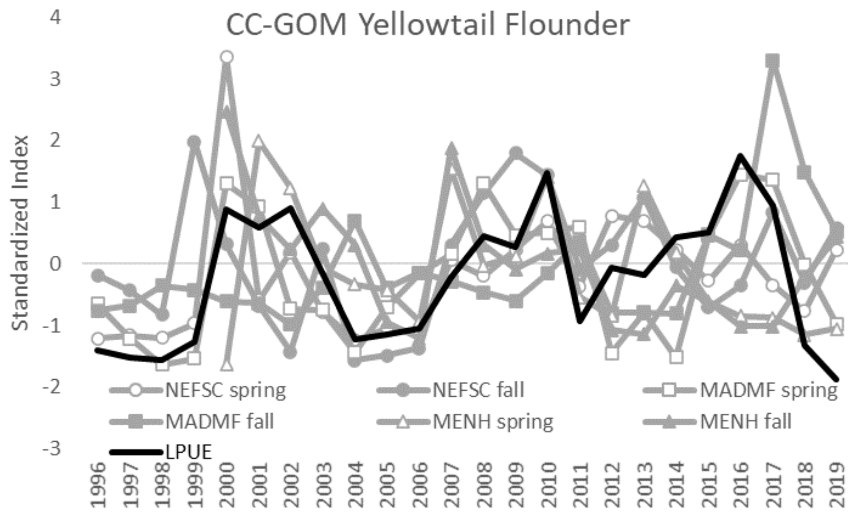
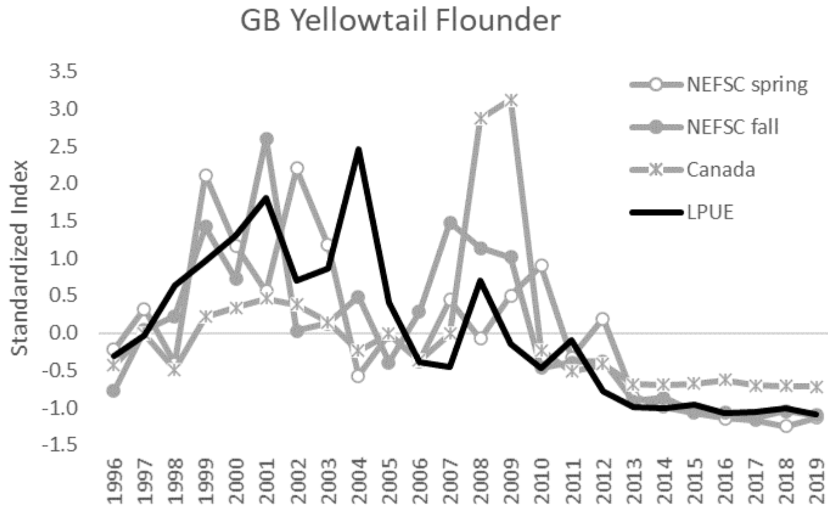


Figure 5. Residual analysis of LPUE standardization for CC-GOM yellowtail flounder.





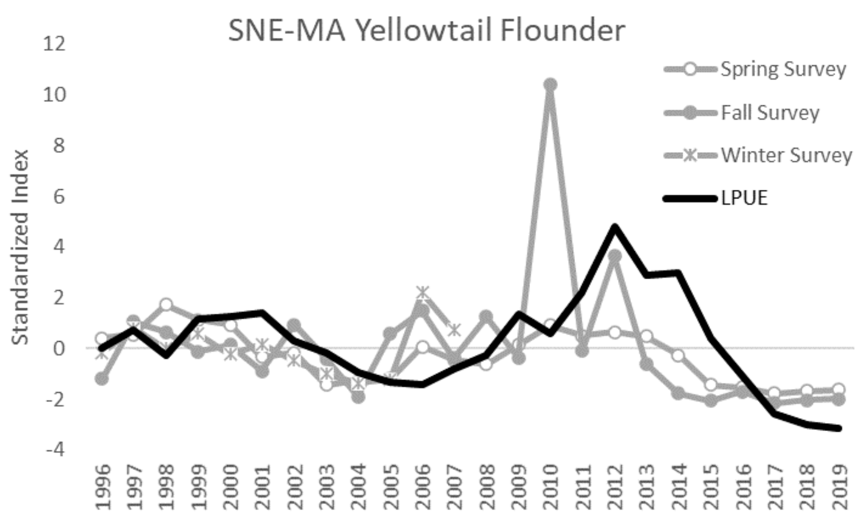


Figure 6. Standardized trawl LPUE and survey biomass indices for New England yellowtail flounder stocks.