

California Scorpionfish 2017 Stock Assessment

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STAR Panel meeting July 24-28, 2017



Background

Catch

Indices

Composition

Biological

Model

Uncertainty

Appendix

California scorpionfish (*Scorpaena guttata*)

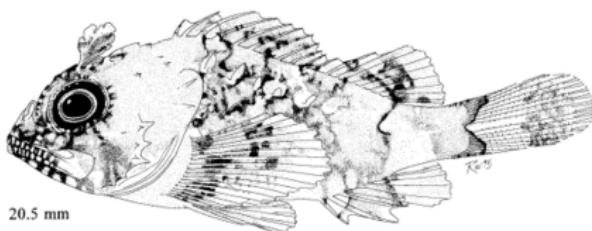
- Most common species of *Scorpaena* on the U.S. West Coast, more species in Mexico
- Venomous dorsal, anal and pelvic spines
- Demersal, found over both hard and soft bottom (anecdotal evidence suggests they prefer new structure)
- Exhibit aggregating behavior (spawning and non-spawning aggregations)



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Early Life History

- Migration to spawning grounds, exhibit explosive breeding behavior just before dawn
- External fertilization, females produce hollow gelatinous single-layer floating egg matrix
- Eggs hatch after about 5 days
- Juveniles settle at less than 2 cm

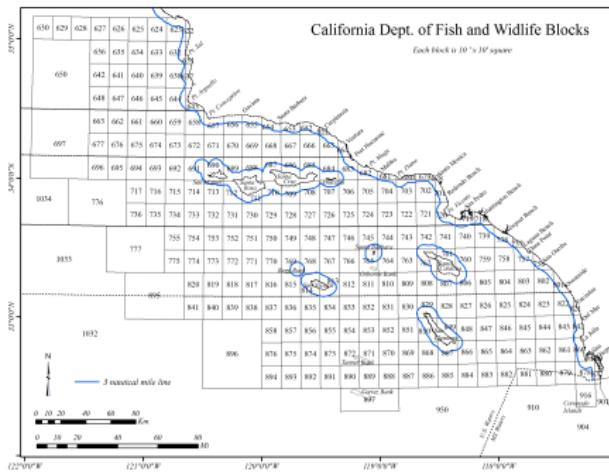
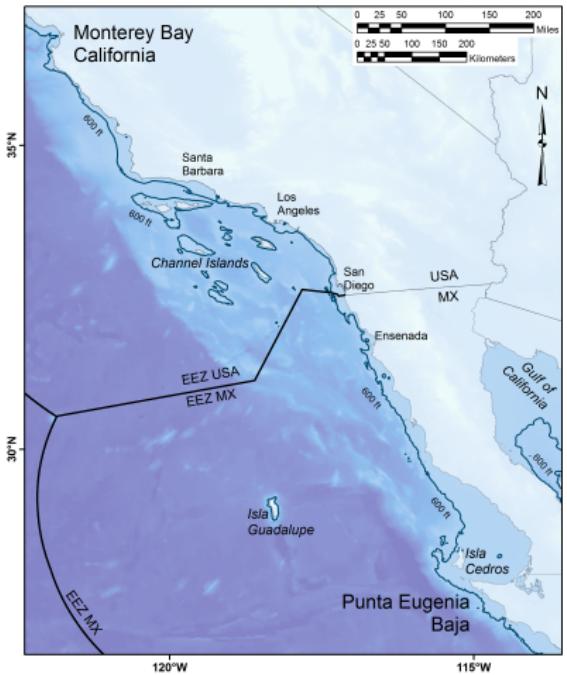


⁰Line drawing from CalCOFI Atlas 33, pg. 789 Figure 26

Distribution

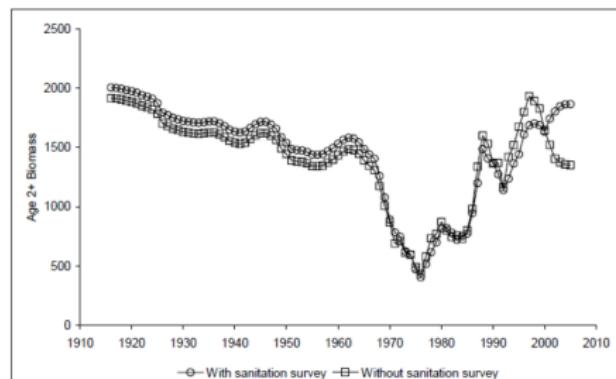
- Distributed from central California to Punta Eugenia, Baja California Sur, Mexico
- Rarely observed north of Pt. Conception
- Observed from the intertidal to 600 ft, prefer depths of 20-450 ft
- Proportion of the stock in Mexican waters unknown

Distribution and Stock Assessment Boundary



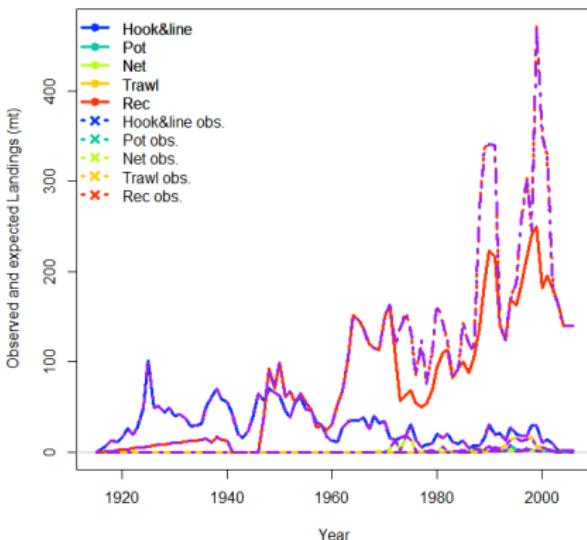
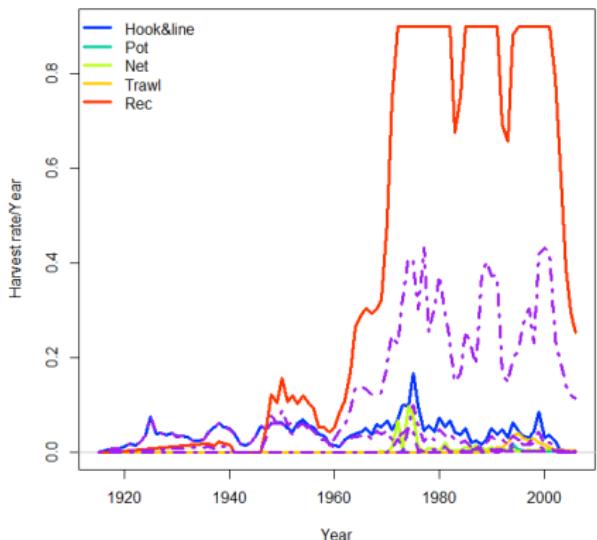
2005 Stock Assessment

- Stock first assessed in 2005
- South of Pt. Conception
- M fixed at 0.25
- h fixed at 0.7
- Publicly Owned Treatment Works (POTW) monitoring trawl survey was the axis of uncertainty in the 2005 assessment
 - POTW survey referred to as the Sanitation District Index in 2005



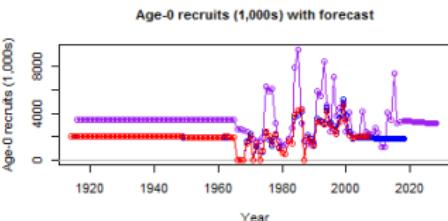
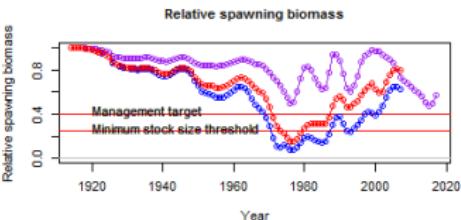
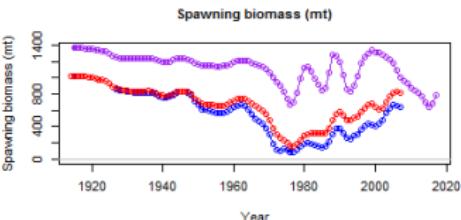
2005 Stock Assessment

- Transitioning from the 2005 assessment, an error was found
- Harvest rate hit the bounds for the recreational fleet
- Not all of the recreational catch was removed in the model
- Input vs. estimated catch was not standard output in SS v.1.8



2005 Stock Assessment

- 2005 assessment, SS v.1.8
- 2005 model in SS3.24z
- 2017 pre-STAR base model, SS3.30.0.05
- The two assessments have very similar trends over time, with B_0 higher for the 2017 assessment that includes all removals

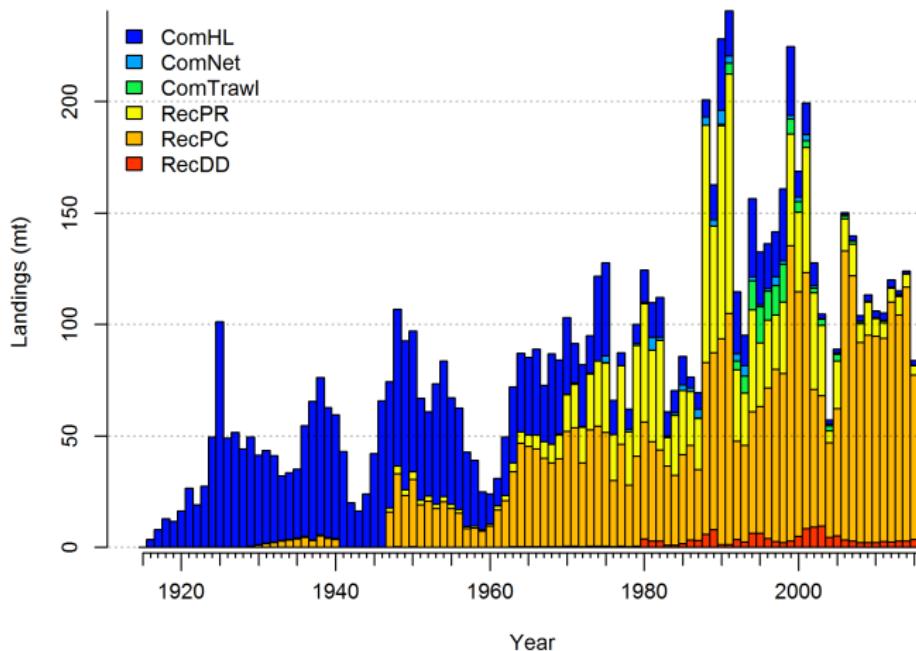


2017 Stock Assessment

Pre-STAR Base Model

- One area south of Pt. Conception
 - Catches from Mexican waters excluded as in 2005
- Steepness fixed at 0.718
- Sex-specific M fixed for females, male M estimated as offset
- Re-evaluated fleet definitions
- Ages now available from the NWFSC trawl survey
- New indices and length compositions available

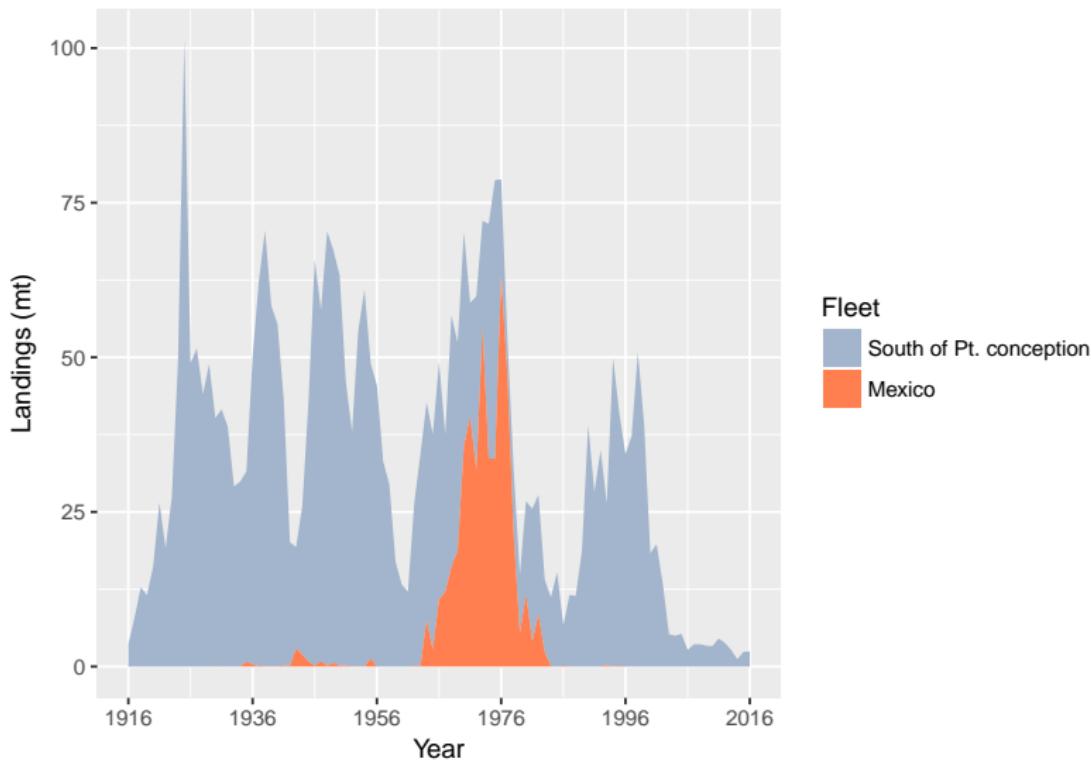
Catches by Fleet



##Regulations **1999**: 10-in min. size limit

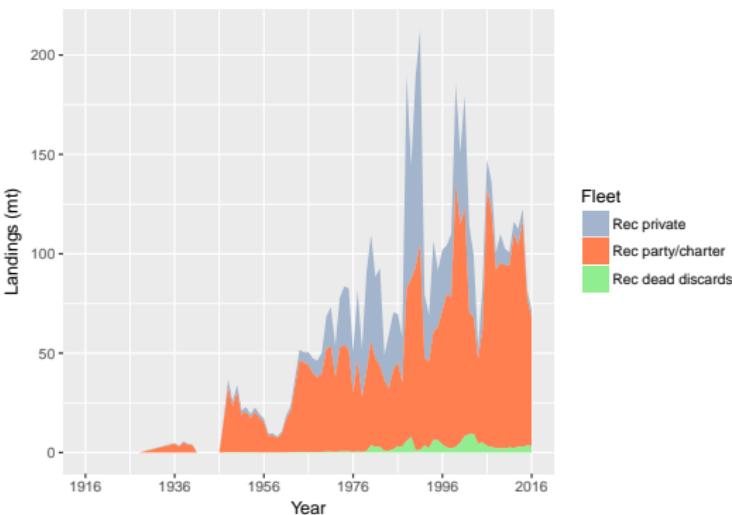
2000: 3 hooks and 1 line **2001**: 2 hooks

U.S. and Mexico Catch



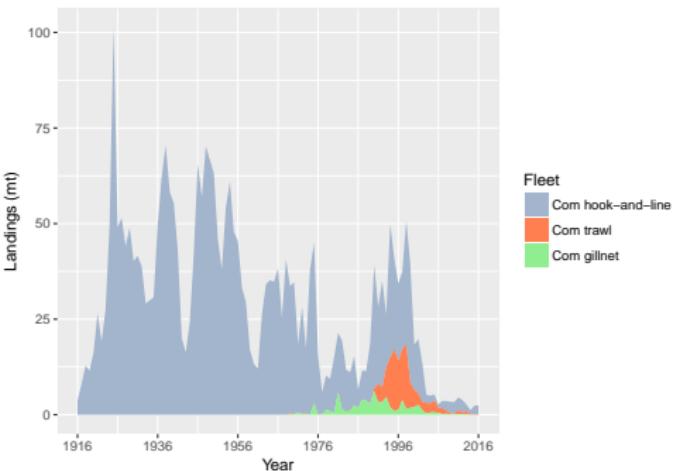
Recreational Catch

- 2005 assessment used number of fish for recreational catches
- 2017 assessment includes one recreational discard fleet
 - Discard mortality rate of 7%
 - Discard biomass accounts for <3% of recreational mortality



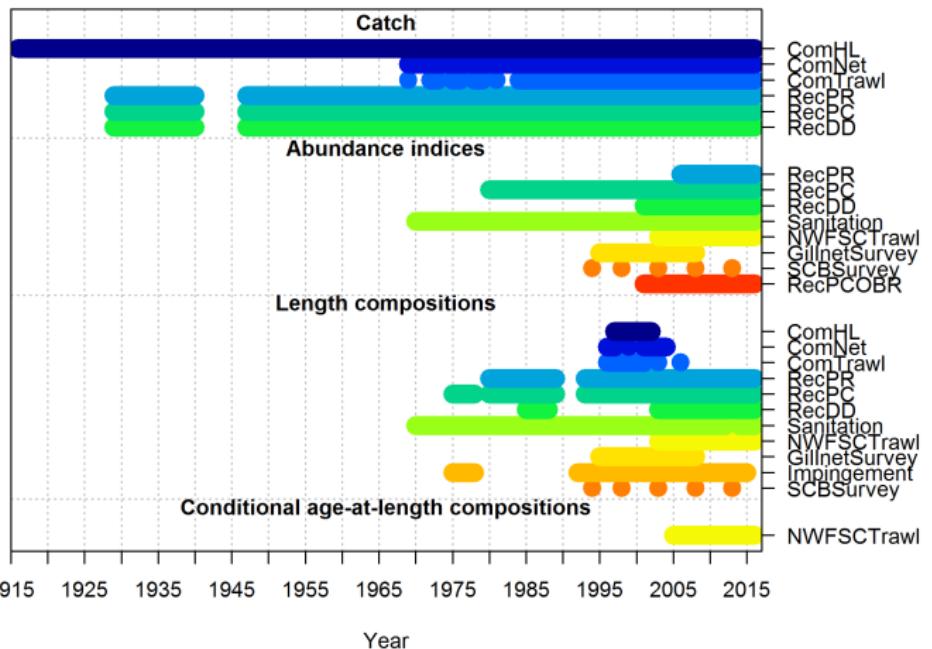
Commercial Catch

- Historical catches same as the 2005 assessment
- California Fisheries Information System (CFIS) landings data used to update catches from 2005-2016
- Discards assumed negligible



Indices of Abundance

Data by type and year



Indices of Abundance

All of the methods used to standardize indices have been endorsed by the SSC

Name	Years	Fishery ind.	Method
Recreational PR dockside CPUE	2004-2016	No	delta-GLM (bin-lognormal)
CPFV logbook CPUE	1980-2016	No	negative binomial
Onboard observer discard catch CPUE	2002-2016	No	delta-GLM (bin-lognormal)
Sanitation district CPUE	1970-2016	Yes	delta-GLM (bin-lognormal)
NWFSC trawl survey CPUE	2003-2016	Yes	VAST
CSUN/VRG Gillnet survey CPUE	1995-2008	Yes	delta-GLM (bin-lognormal)
Southern California Bight trawl survey CPUE	'94, '98, '03, '08, '13	Yes	delta-GLM (bin-lognormal)
Onboard observer retained catch CPUE	2002-2016	No	delta-GLM (bin-lognormal)

Indices of Abundance

Delta-GLM Approach

- Approach used for all indices except the NWFSC trawl survey and the CPFV logbook
- Two-part model
 - Binomial fit to the presence-absence data
 - Lognormal or Gamma fit to positives
- General approach
 - Filter data to identify most appropriate samples
 - Model selection
 - Gamma or Lognormal for positives
 - Covariates for each of the two models chosen using AIC
 - Uncertainty for final model estimated via jackknifing

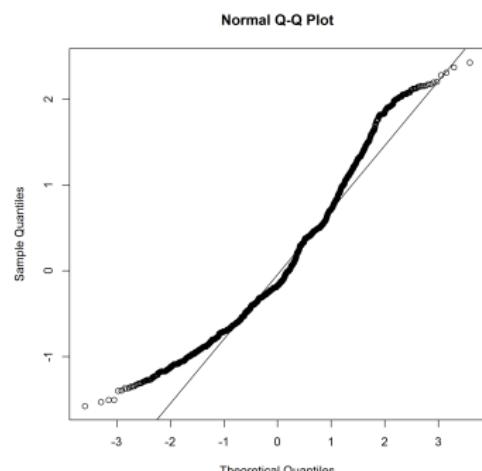


Recreational Dockside Private Boat Index

Sample: California CRFS only; **Years:** 2006-2016; **Effort:** Angler days

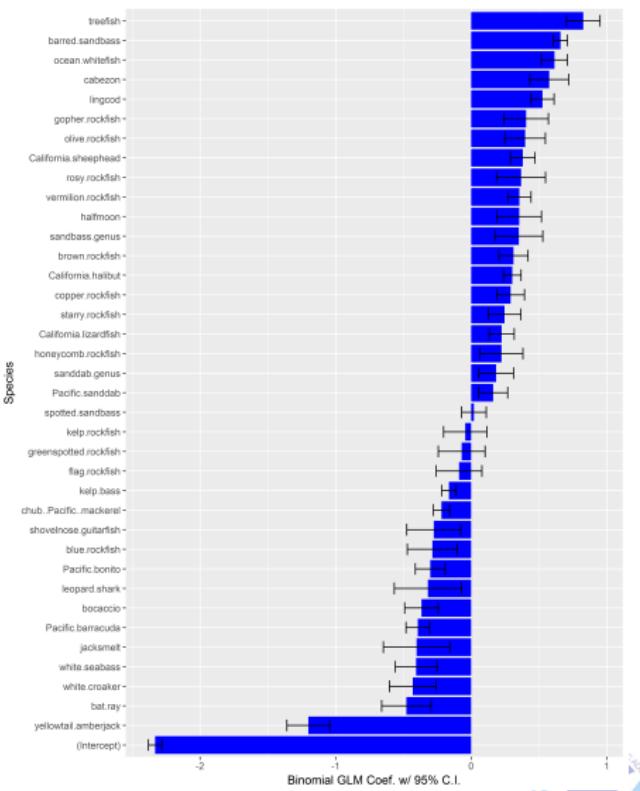
Filter	Criteria	Pos. Trips	Trips
Entire dataset		108,171	
General data filters	CRFS-PR1 survey only, Southern California only (sub_reg = 1), Hook and line gear only (geara = 'H'), Ocean only (Area_X = 1 or 2)	3,802	43,956
Region	Remove trips from Santa Barbara	3,757	42,956
Year	Remove 2004-2005; fishery closed majority of year	3,094	33,770
Closed fishery	Remove remaining trips when fishery closed	3,056	32,236
Rare and co-occurring species	Remove trips with yellowfin tuna and dolphinfish and species present in <1% of all trips and in at least 5 years of data	3,056	30,033
Stephens-MacCall	Retain all positive trips, plus "False Positives" (trips predicted to be in California scorpionfish habitat, but with no California scorpionfish retained)	3,056	8,590

Model	Binomial	Lognormal
Year	6182	8103
Year + County	5862	8003
Year + Wave	6091	8092
Year + County + Wave	5792	8000



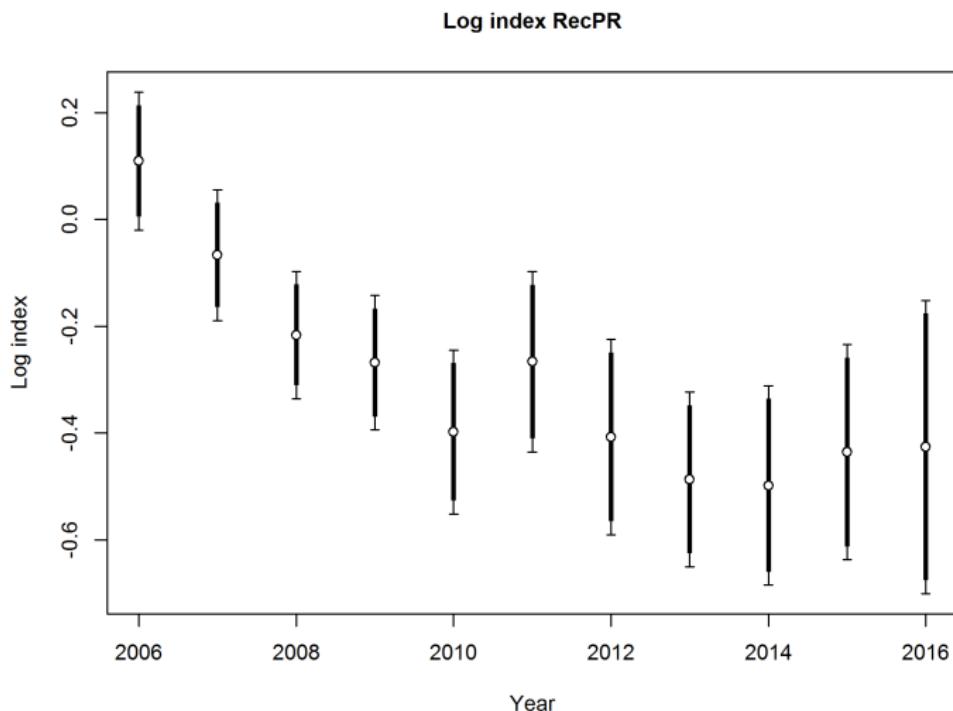
Recreational Dockside Private Boat Index

- Positive indicators: treefish, barred sandbass, ocean whitefish, cabezon
- Negative indicators: yellowtail amberjack, bat rays, white croaker, white seabass
- Similar indicator species as in the MRFSS party/charter analysis



Recreational Dockside Private Boat Index

Results



Recreational CPFV Logbook Index

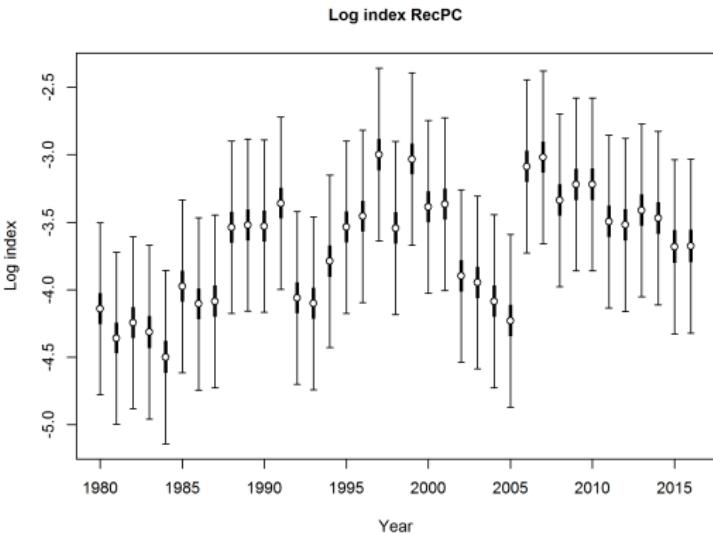
Sample: Captain-reported catch; **Years:** 1980-2016; **Effort:** Angler hours

Filter	Criteria	Trips
All CA data	No filter	1,164,662
Gear	Remove trips reported as diving, mooching or trolling	959,740
Effort or missing data	Remove trips with missing effort or species information	930,233
Year	Remove 2017, remaining years 1980-2016	929,781
Region	Remove trips north of Pt. Conception and in Mexico	568,222
Fish encountered	Remove trips reporting number of retained fish greater than in the 99% quantile (>325 fish)	564,433
Target species	Remove trips targeting sharks, striped bass, sturgeon, tuna, misc. bay, and potluck	558,872
Single-species trips	Filter trips reporting catches of only species and that one species in <100 trips	558,833
Offshore trips	Remove trips catching yellowtail, tunas, and dolphinfish that were not designated as offshore trips	475,492
Vessel	Remove trips by vessels that had fewer than 10 trips catching scorpionfish	466,023
Anglers	Remove trips with number of anglers < the 1% and > the 99% quantile (retain 5-75 anglers)	452,938
Depth	Remove trips in blocks with a minimum depth of >140m	443,929
Scorpionfish targets	Blocks with at least 100 scorpionfish trips	433,248
Sample size	Blocks with at least 500 trips	432,868

Recreational CPFV Logbook Index

Results

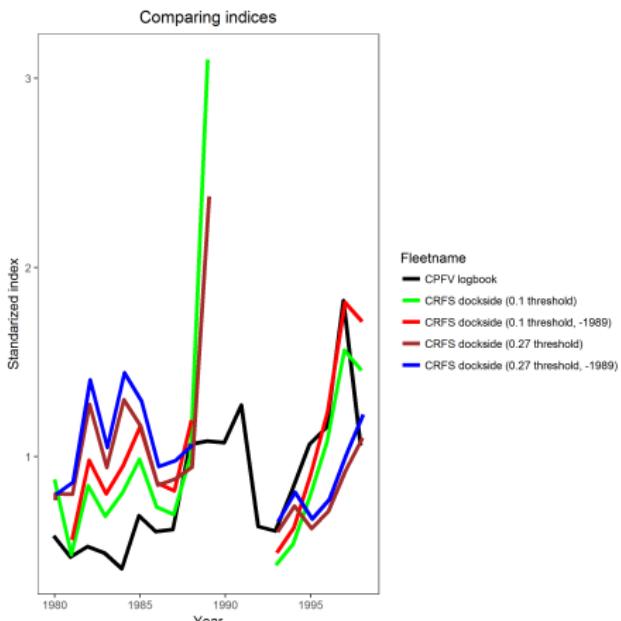
Model	Negative Binomial
Year	1918470
Year+ Month	1901592
Year + Block	1872224
Year+ Month + Block	1854652



Recreational Dockside Party/Charter Boat Index

Sample: California MRFSS ; **Years:** 1980-2003; **Effort:** Angler hours

- *Index not used in the assessment*
- No MRFSS sampling from 1990-1992
- Index sensitive to Stephens-MacCall threshold
- Dockside index estimate for 1989 is high and anomalous
- Data redundant with the CPFV logbook index
- 1989 estimate lower if a higher threshold is used



Recreational Onboard Indices

Sample: Drift-level catch **Years:** 1999-2016 **Effort:** Angler hours

- Drift-level catch data collection onboard CPFVs
- Alpha hull method used to select suitable habitat for California scorpionfish
- Assume that suitable habitat is the same for discarded and retained fish

Filter	Criteria	Pos. trips	Trips
Initial SQL filtering		6,475	59,192
Habitat filter	Remove drifts >1000 m of alpha hull buffer, remove "reefs" with <0 drifts or 5% positives, or in CCA	6,365	30,987
Exclude 1999 and 2000	Management changes (depth and gear restrictions)	5,986	29,577
Depth	Remove upper and lower 1% of data (retain 26-330ft)	5,921	29,002
Minutes Fished	Remove upper and lower 1% of data (retain 4 - 155 minutes)	5,780	28,460
Observed Anglers	Remove upper and lower 1% of data (retain 4 - 15 anglers)	5,679	27,946
Boats	Include boats encountering scorpionfish in at least 3 years; at least 30 drifts and 10 with scorpionfish	5,509	26,805
Second depth filter	Remove anything >100 m after looking at 20 m depth bins	5,507	26,733



Recreational Onboard Indices

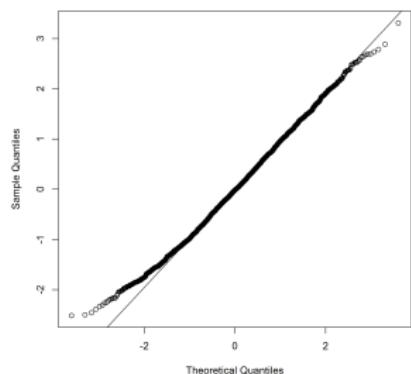
Discarded Catch

Model	Binomial	Lognormal
Year	19619	9177
Year + Reef	18677	9177
Year + Depth	19374	8860
Year + Depth + Reef	18392	8778
Year + Month + Reef + Depth	18318	8769

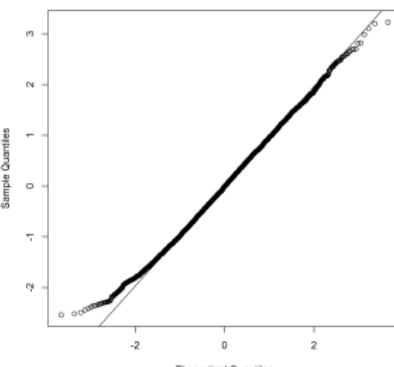
Retained Catch

Model	Binomial	Lognormal
Year	21826	11507
Year + Reef	21192	11325
Year + Depth	21265	10704
Year + Depth + Reef	20691	10619
Year + Month + Reef + Depth	20453	10599

Normal Q-Q Plot

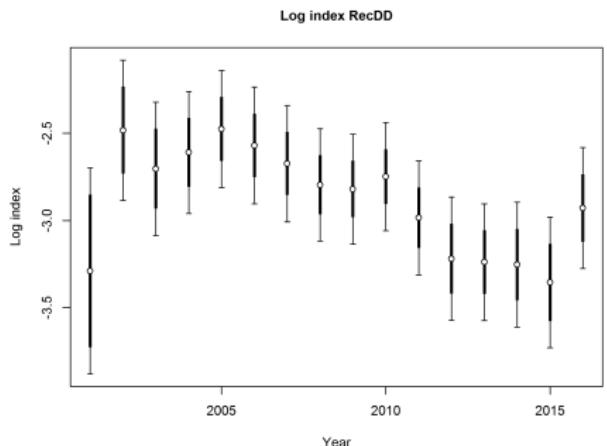


Normal Q-Q Plot

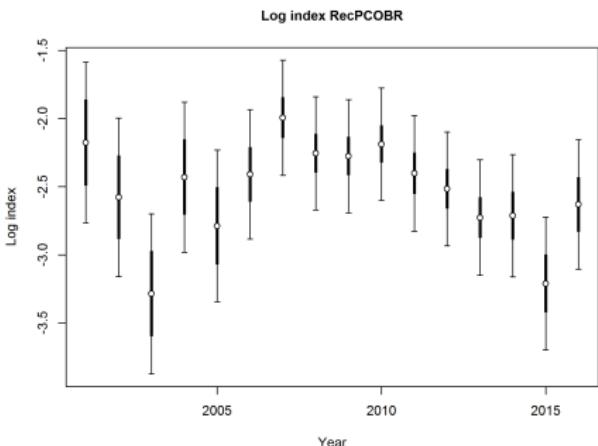


Recreational Onboard Indices

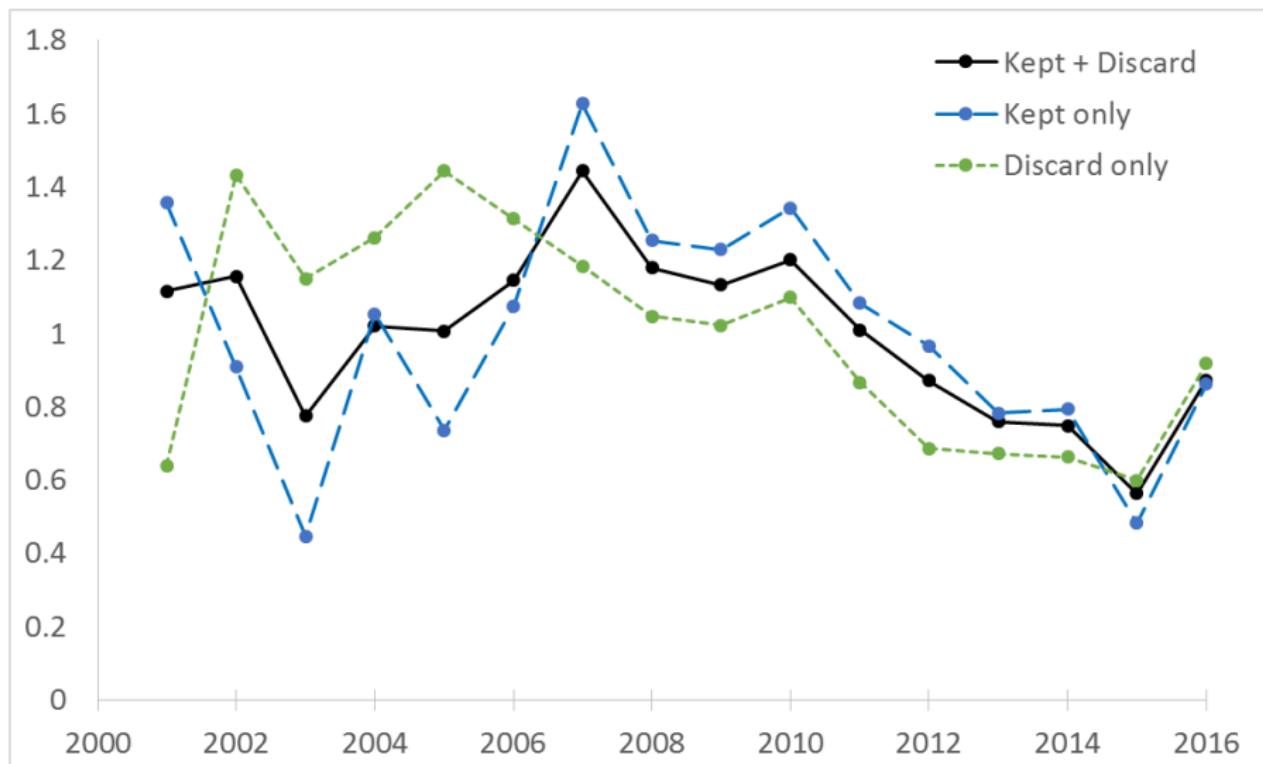
Discard catch index (left)



Retained catch index (right)



Recreational Onboard Indices



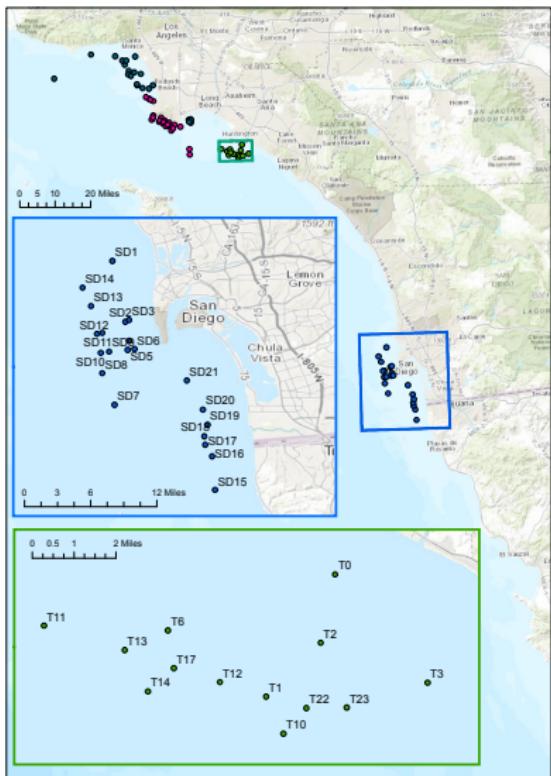
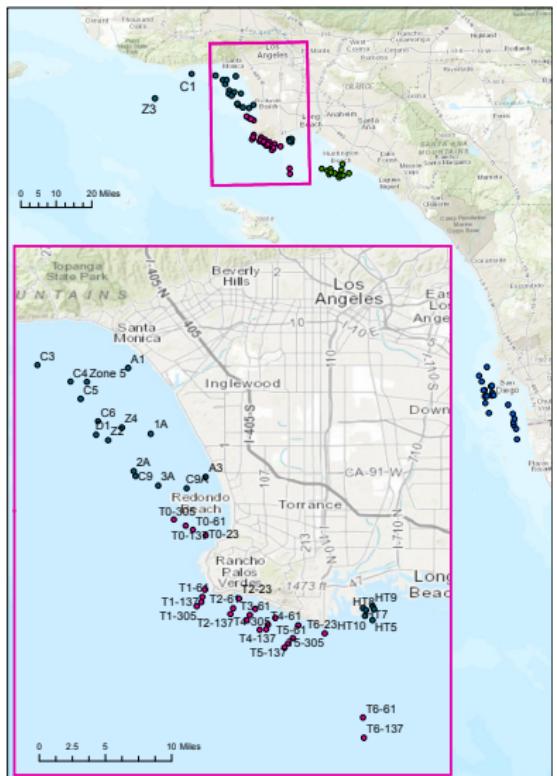
Fishery-Independent Abundance Indices

- Publicly Owned Treatment Works (POTW) Monitoring Index
- NWFSC Trawl Survey
- California State University Northridge/Vantuna Research Group (CSUN/VRG) Gillnet Survey
- Generating Station Impingement Survey
- Southern California Bight Regional Monitoring Survey (Bight survey)

Publicly Owned Treatment Works Survey Index

- Publicly Owned Treatment Works (POTWs) are required to have permits to discharge into state or federal waters
- Six southern California POTWs conduct trawls to monitoring fish populations (Goleta and City of Oxnard do not observe California scorpionfish)
 - Each POTW follows standardized trawl methods
 - Fixed station design, sample spring and fall, or more frequently
 - All fish encountered are measured, standard length
- Four POTWs observed California scorpionfish
 - Orange County Sanitation District (1970-2016)
 - City of Los Angeles Environmental Monitoring Division (1988-2016)
 - Sanitation Districts of Los Angeles County (1972-2016)
 - City of San Diego Public Utilities Department (1985-2016)

POTW Survey Index



Publicly Owned Treatment Works Survey Index

Sample: Four POTWs **Years:** 1970-2016 **Effort:** Tow time

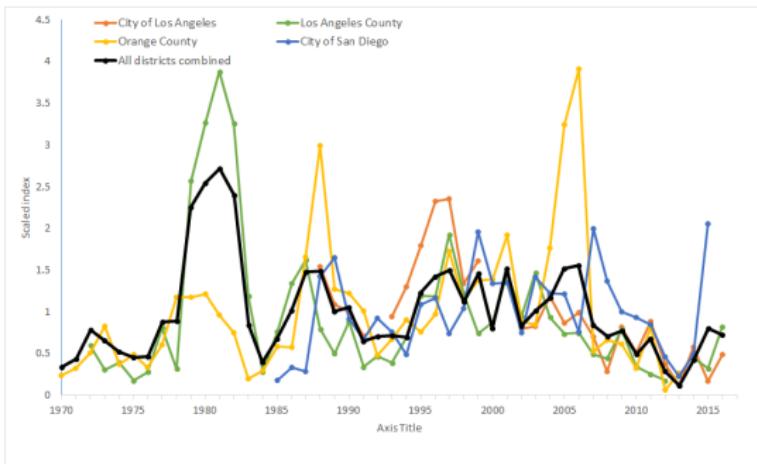
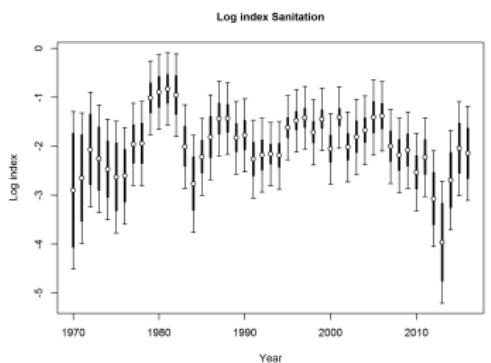
Number of California scorpionfish encountered by POTW and 25 m depth bin

Program	0-24 m	25-49 m	50-74 m	100+ m	Total
City of Los Angeles	120	0	1372	0	1492
Los Angeles County	687	0	5879	450	7016
Orange County	161	669	2157	48	3035
City of San Diego	0	404	333	829	1566



Publicly Owned Treatment Works Survey Index

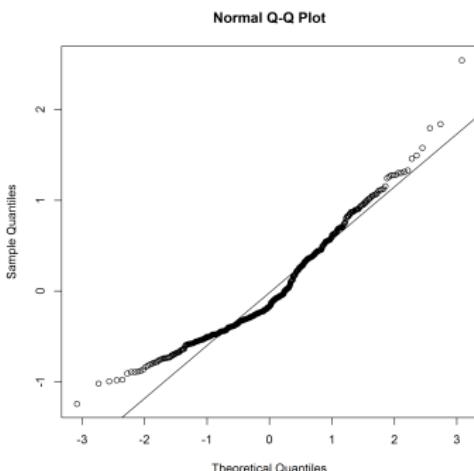
Results



Gillnet Survey Index

Sample: CSUN/VRG survey **Years:** 1995-2008 **Effort:** Soak time

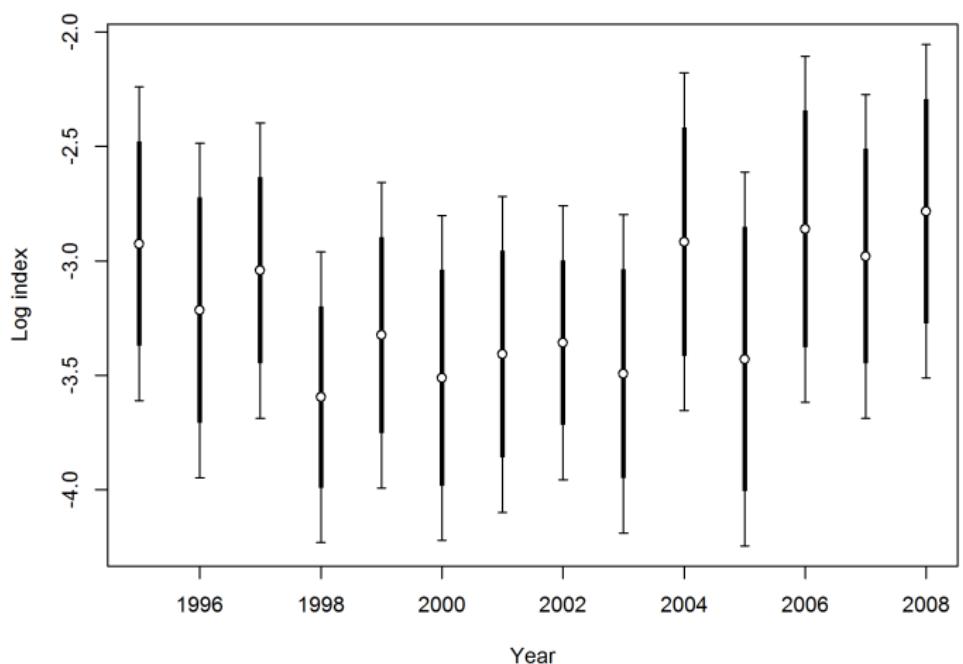
Filter	Criteria	Pos. trips	Trips
Entire dataset		325	3,558
General data filters	Samples with no net failures	269	3,515
Net type	Samples using a net type 1", 1.5" and 2" mesh	269	2,815
Sites	Sites frequently sampled	266	2,170
Month	Months sampled consistently (April, June, August, October)	259	2,019



Model	Binomial	Lognormal
Year + month + site + perp_para + floats	1983	1008
Year + site + perp_para + floats	2000	1004
Year + month + perp_para + floats	2349	1264
Year + site + perp_para	2010	1004

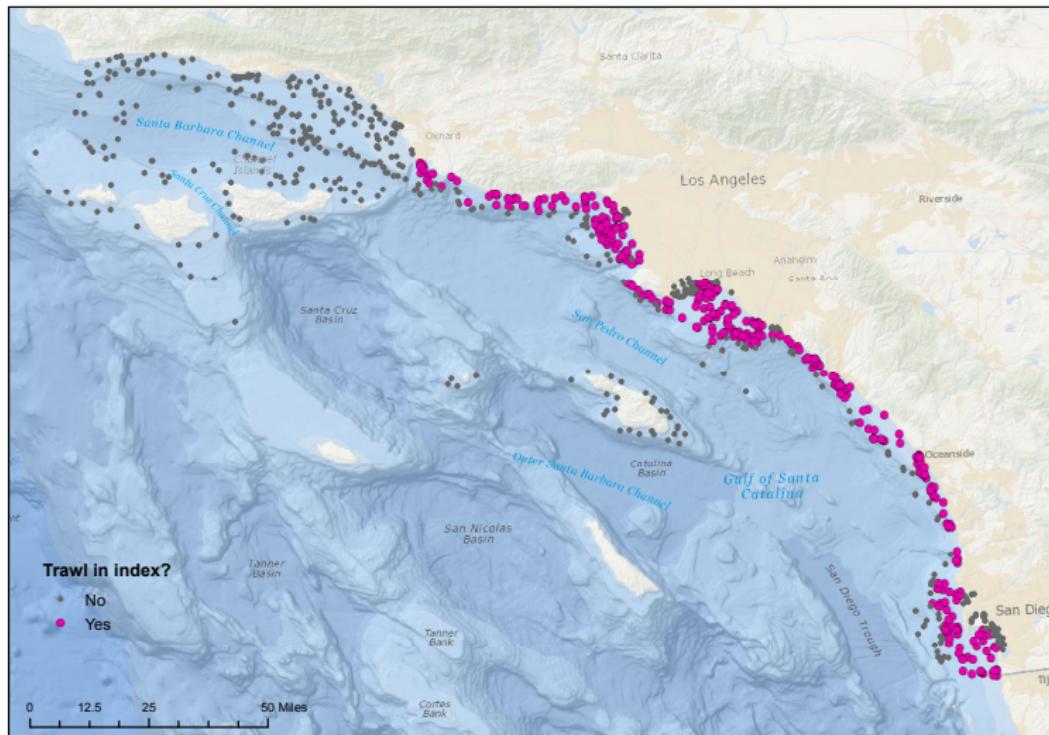
Gillnet Survey Index

Log index GillnetSurvey



Southern California Bight Trawl Survey Index

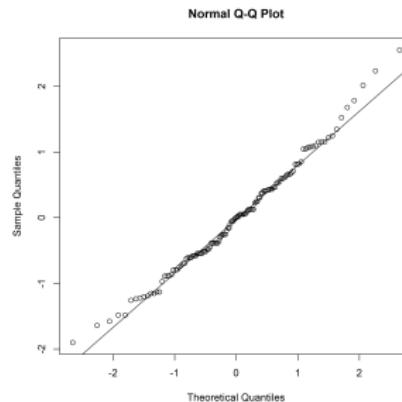
Sample: Bight Trawl Survey **Years:** 1994, 1998, 2003, 2008, 2013 **Effort:** Tow time



Southern California Bight Trawl Survey Index

Filter	Criteria	Pos. trips	Trips
All trawls	No filter	158	944
Depth	Trawls < 98 m (retains 95% of all data)	149	662
Region	Exclude trawls in harbors, north of Ventura and islands (few scorpionfish)	129	398

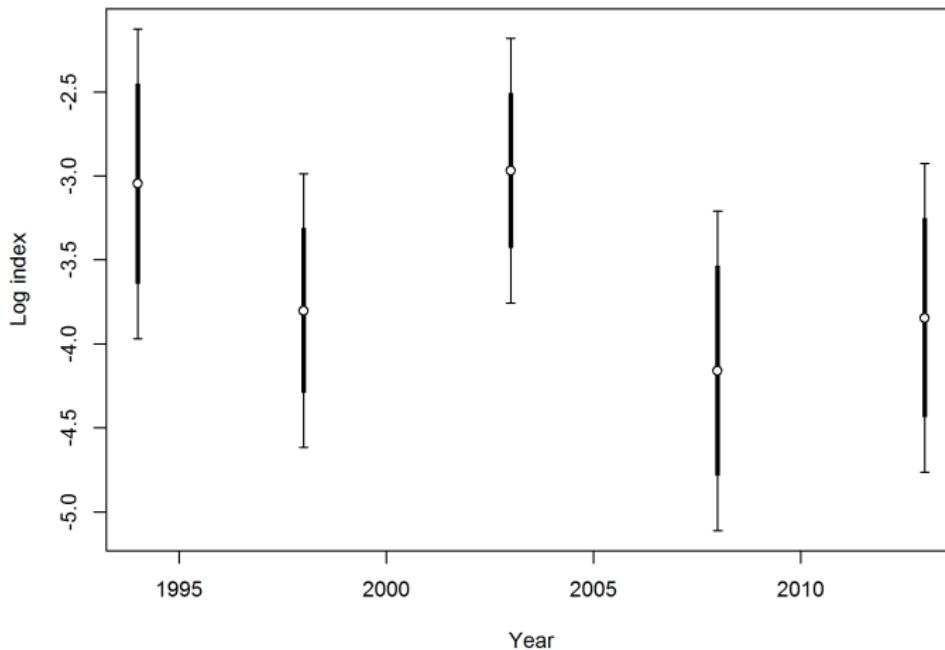
Model	Binomial	Lognormal
Year	494.73	339.56
Year + Region	490.24	343.16
Year + Month	493.02	336.68
Year + Month + Region	486.55	337.87



Southern California Bight Trawl Survey Index

Results

Log index SCBSurvey



NWFSC Trawl Survey Index

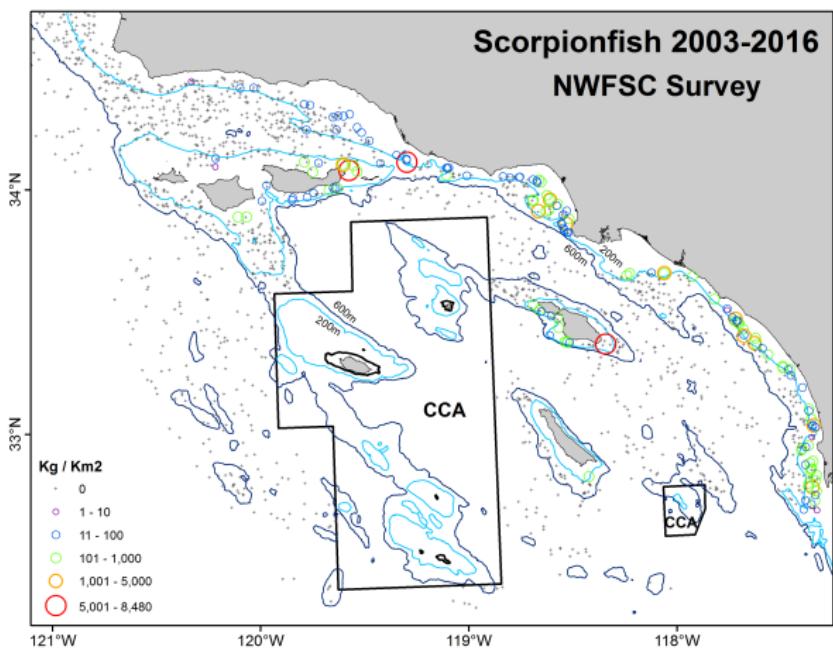
Geostatistical approach Vector Autoregressive Spatio-Temporal (VAST) model

- Uses delta-GLMM framework
 - Probability of encounters
 - Catch rates for non-zero catches
- Geostatistical approach
 - Divides survey area into fine-scale grids
 - Assumes that nearby grids have more similar fish density than those further away
 - Smooths density estimates over the landscape
 - Reduces uncertainty in the estimates



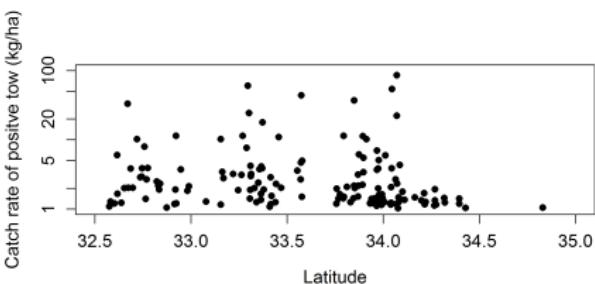
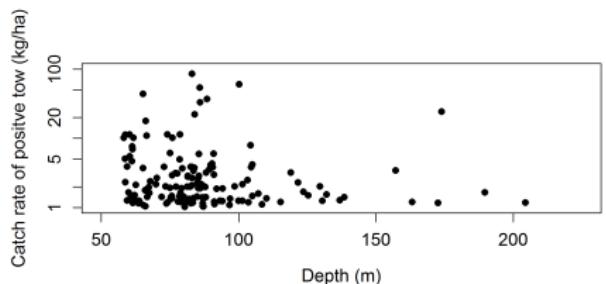
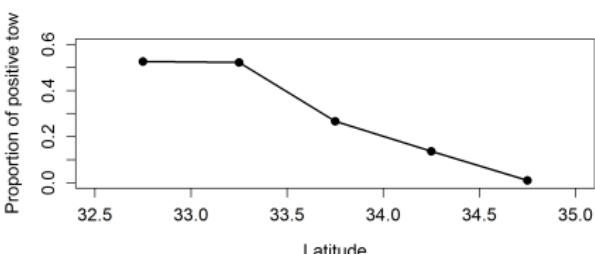
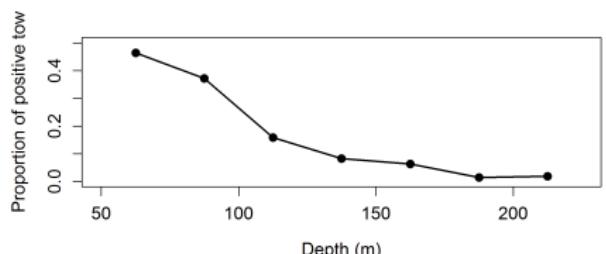
NWFSC Trawl Survey Index

Sample: California MRFSS and CRFS **Years:** 1980-2003 **Effort:** Angler hours



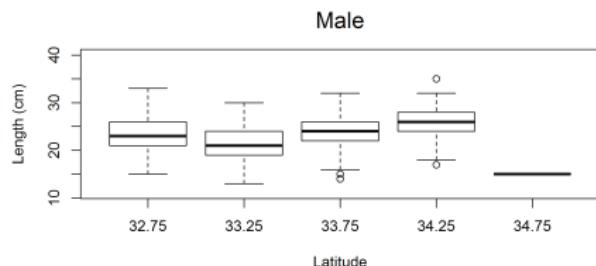
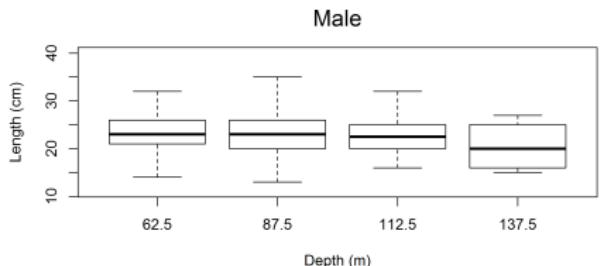
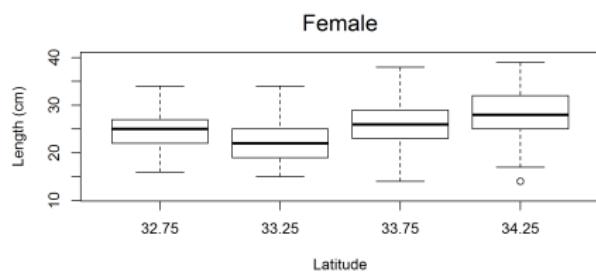
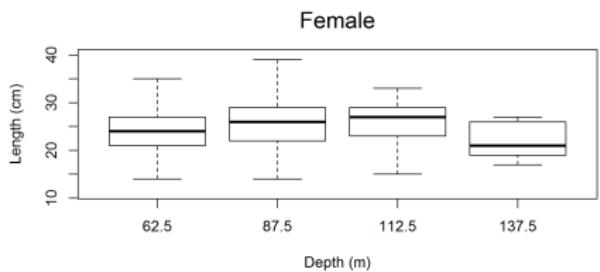
NWFSC Trawl Survey Index

Proportion of positive tows and raw catch rate by depth (left) and latitude (right)

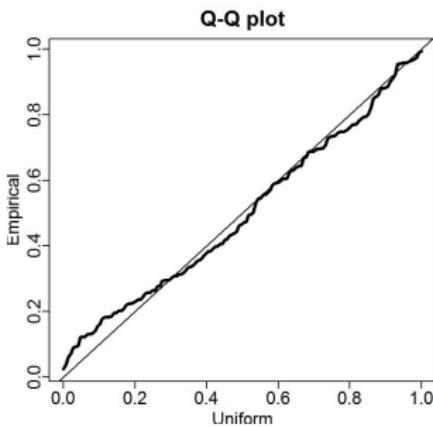
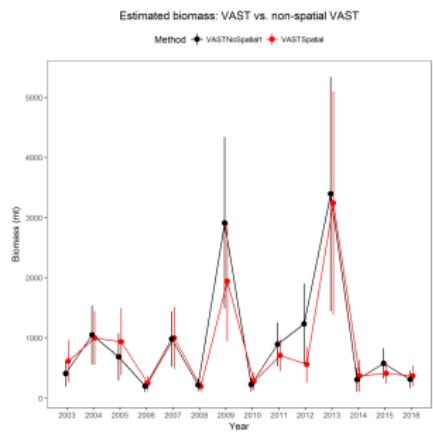


NWFSC Trawl Survey Index

Comparison of length data by sex and depth (left) and latitude (right)



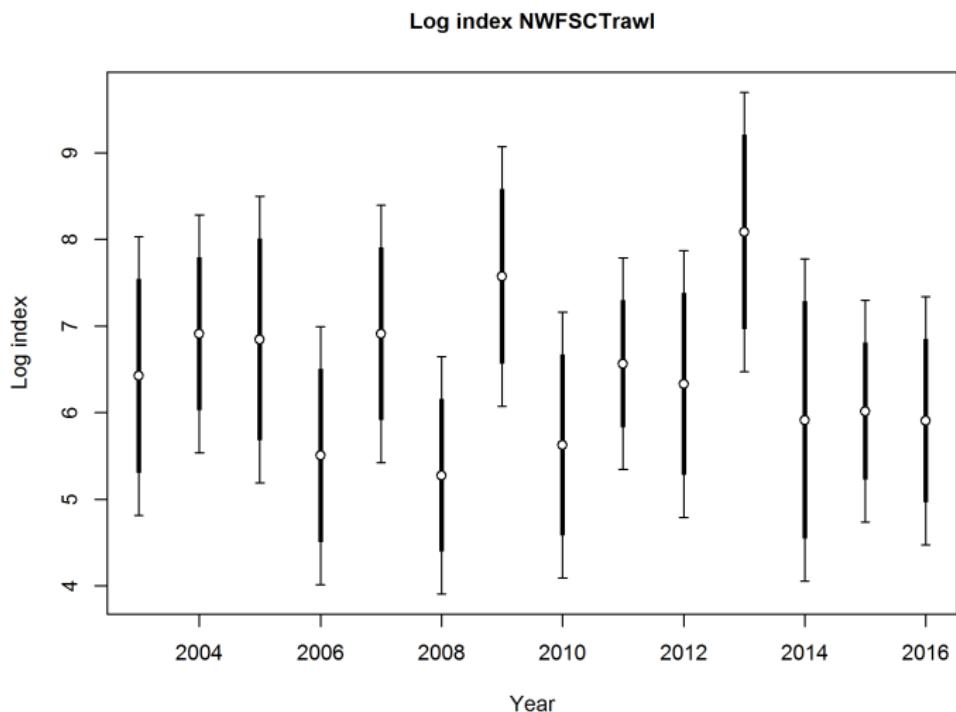
NWFSC Trawl Survey Index



NWFSC Trawl Survey Index

Comparison with the GLMM

NWFSC Trawl Survey Index

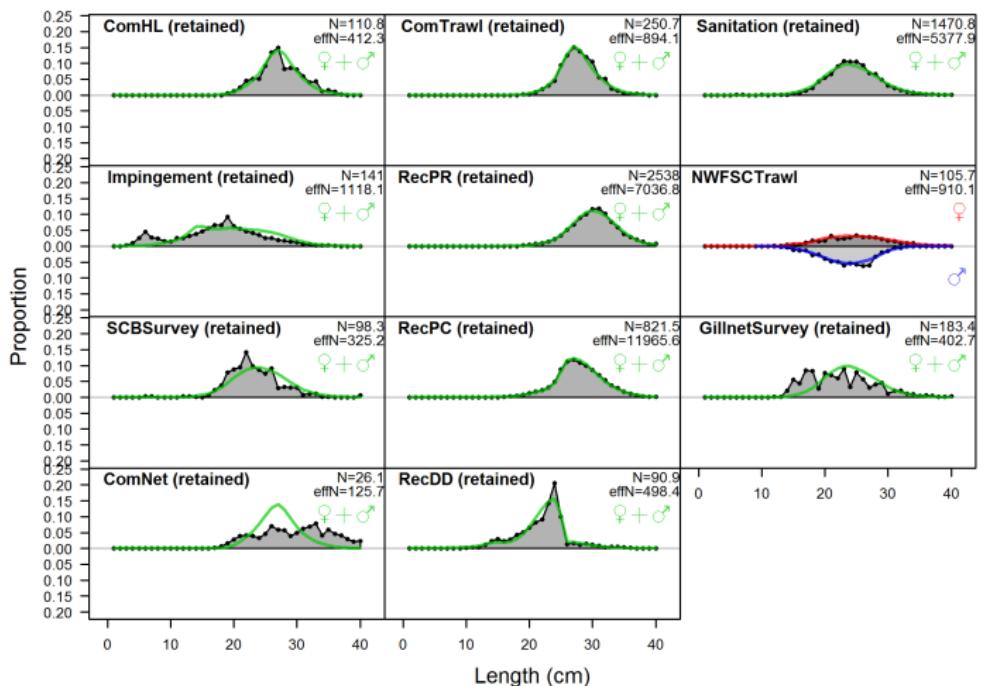


Length compositions were provided from the following sources:

- CDFW market category study (*commercial dead fish*, 1996-2003)
- CALCOM (*commercial dead fish*, 2013-2016)
- CDFW onboard observer (*recreational charter discards*, 2003-2016)
- Collins and Crooke onboard observer surveys (1975-1978)
- Ally onboard observer study (*recreational charter kept/discards*, 1984-1989)
- MRFSS (1980-2003) and CRFS (2004-2014) (*private and party/charter, kept*)
- POTW trawl surveys (*research*, 1970-2016)
- CSUN/VRG gillnet survey (*research*, 1995-2008)
- Power plant impingement surveys (*research*, 1974-2016)
- Southern California Bight trawl survey (*research*, 1994, 1998, 2003, 2008, 2013)

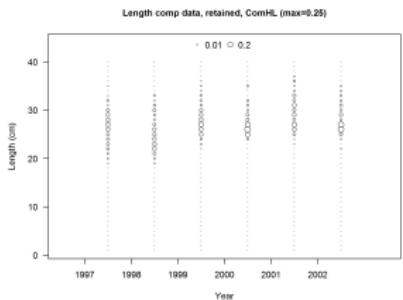
Aggregate length composition

Length comps, aggregated across time by fleet

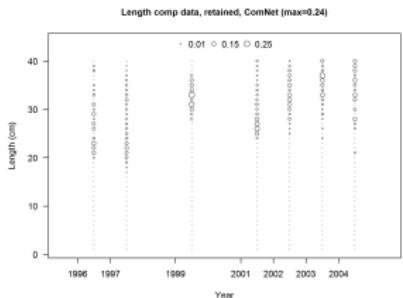


Commercial fishery length composition

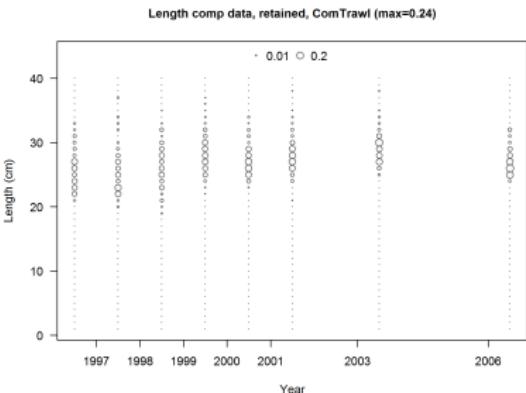
Commercial hook-and-line



Commercial gillnet



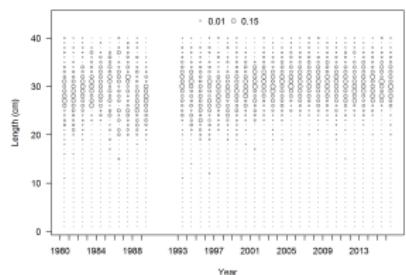
Commercial trawl



Recreational fishery length composition

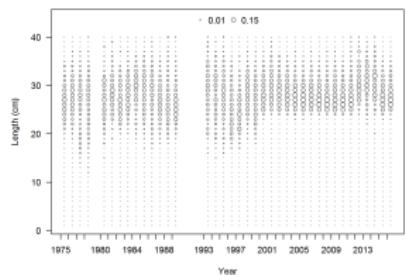
Recreational private fleet

Length comp data, retained, RecPR (max=0.19)



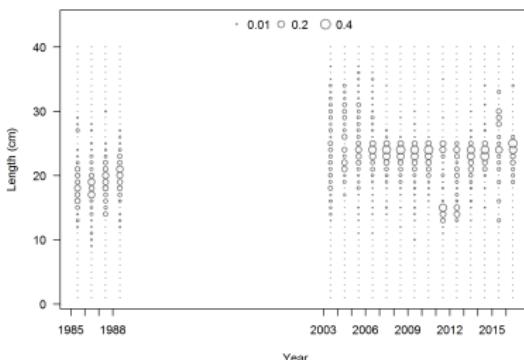
Recreational party/charter fleet

Length comp data, retained, RecPC (max=0.18)



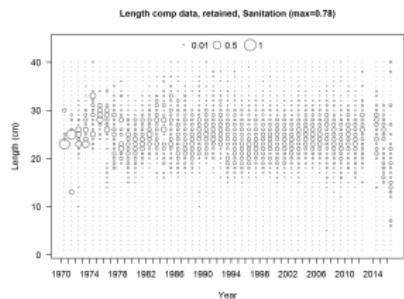
Recreational dead discards

Length comp data, retained, RecDD (max=0.32)

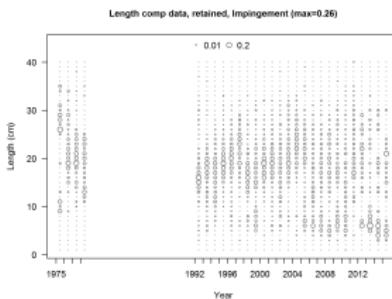


Research length composition

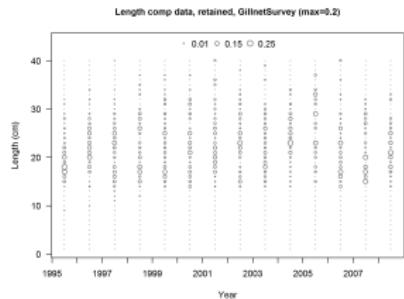
POTW survey



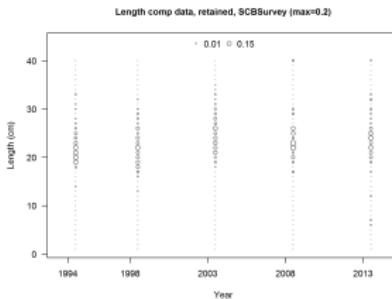
Impingement survey



Gillnet survey



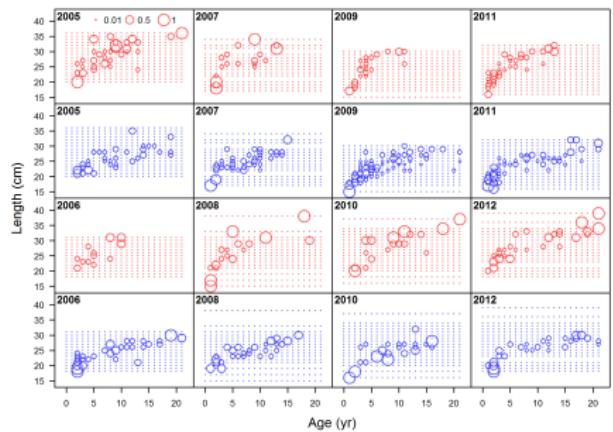
Bight trawl survey



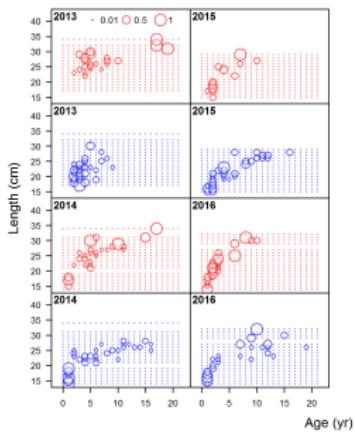
NWFSC length and age composition

Note: females in red and males in blue

Conditional age-at-length data, whole catch, NWFSC Trawl (max=1)

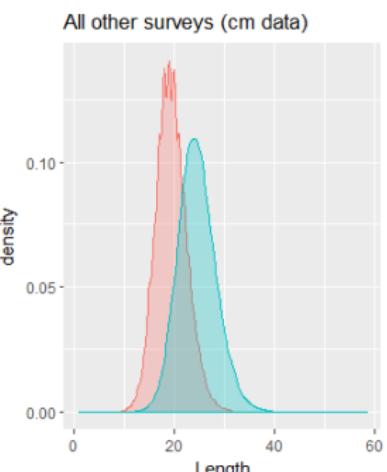
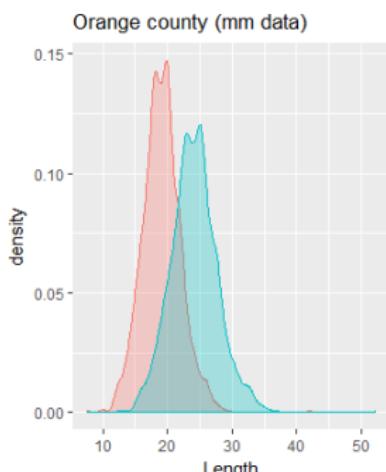


Conditional age-at-length data, whole catch, NWFSC Trawl (max=1)



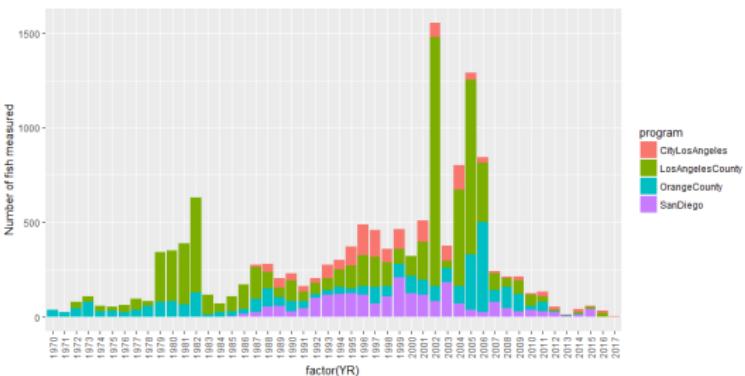
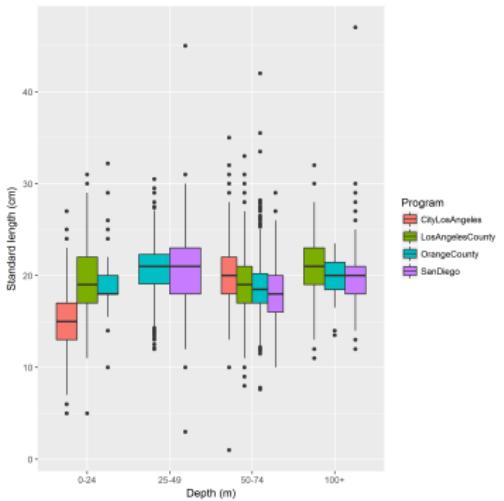
Length data

- 2005 assessment used standard length
- Impingement, POTW, and Bight surveys measure standard length
- 2017 assessment uses total length (conversion based on a CDFW halibut trawl study; measured both SL and TL)
- To avoid gaps in TL length bins, $TL = SL - 0.5 + U[0,1]$

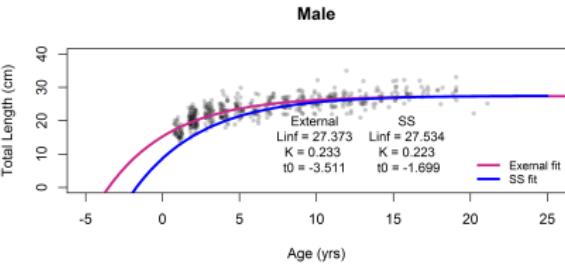
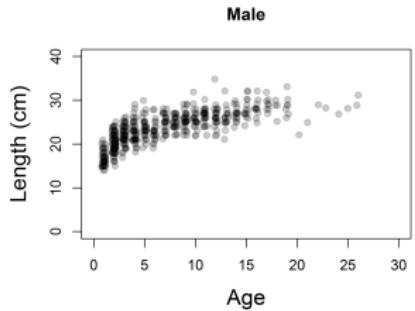
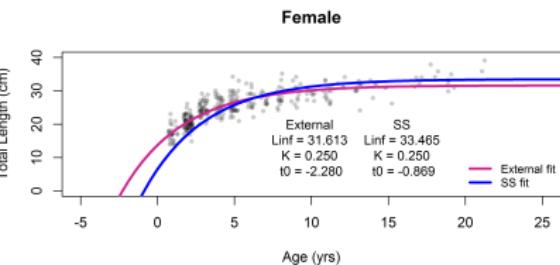
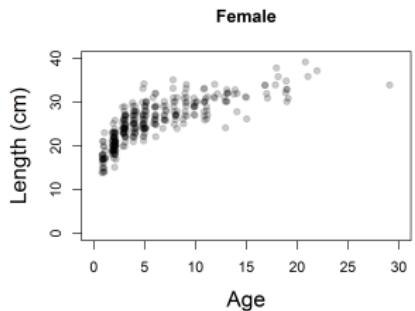


Length data

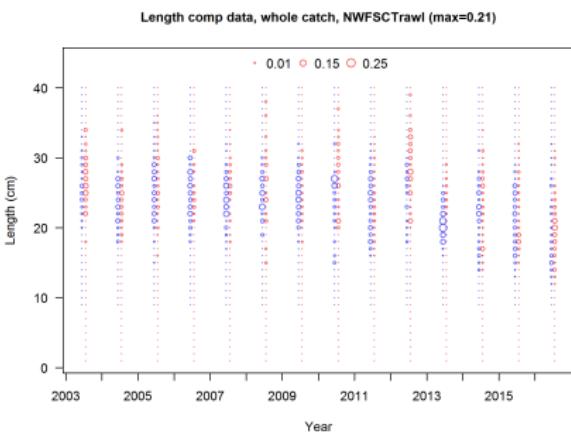
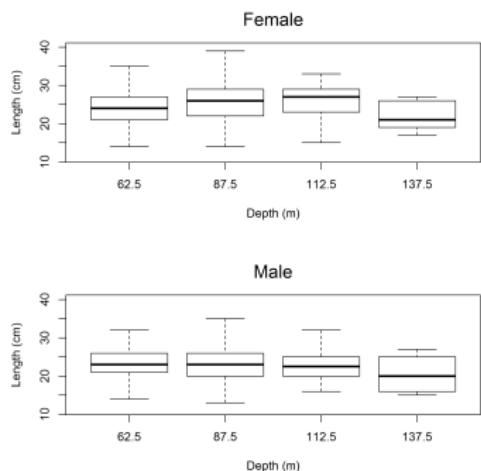
POTW lengths



Length-at-age

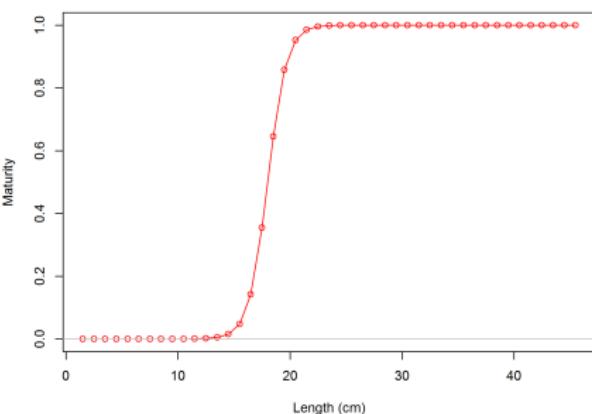


Length-at-age

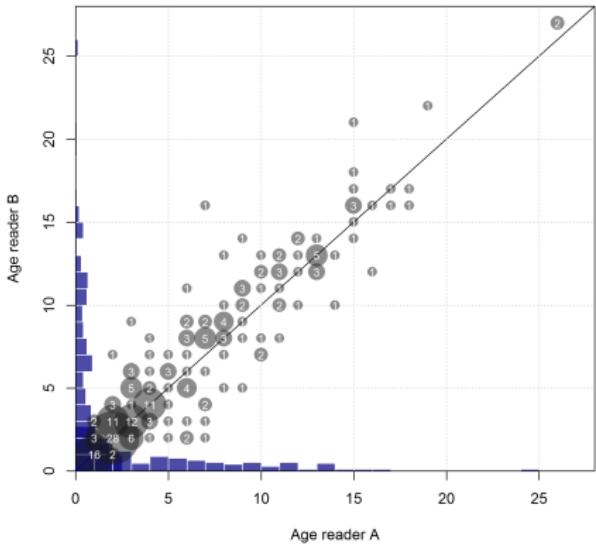
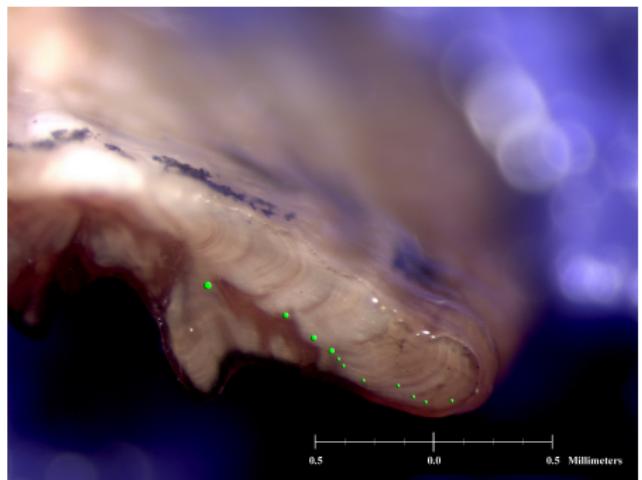


Maturity and Fecundity

- Only information on maturity from Love et al. (1987)
- Found over 50% of females were mature by 18 cm TL, or two years of age.
- All fish were mature by 22 cm TL
- No information available on fecundity of California scorpionfish



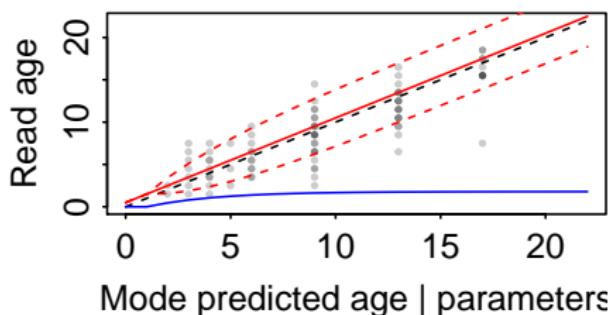
Ageing Error



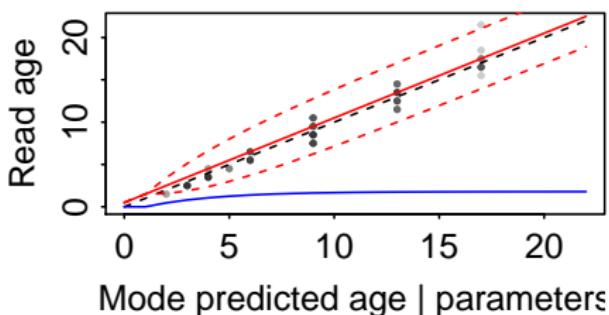
Ageing Error

Reads(dot), Sd(blue), expected_read(red solid line),
and 95% CI for expected_read(red dotted line)

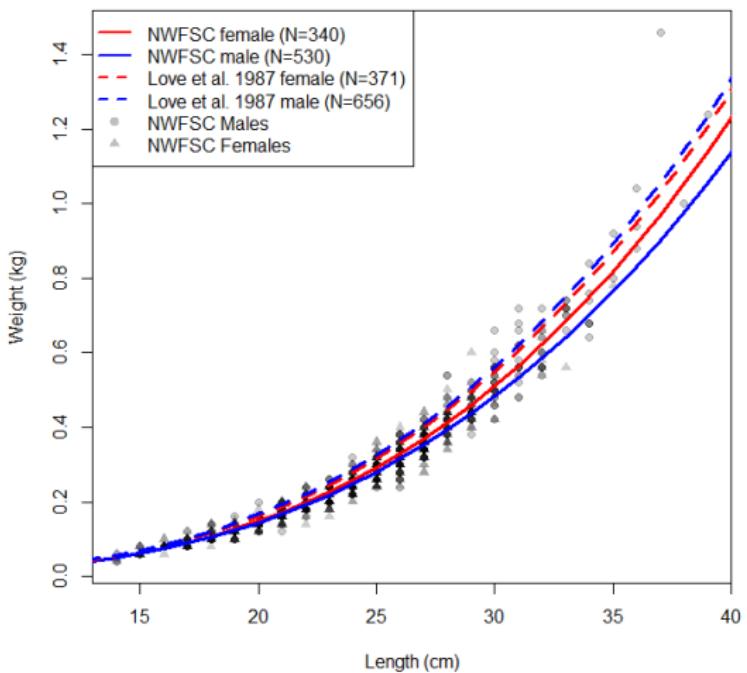
Reader 1



Reader 2



Weight-at-length



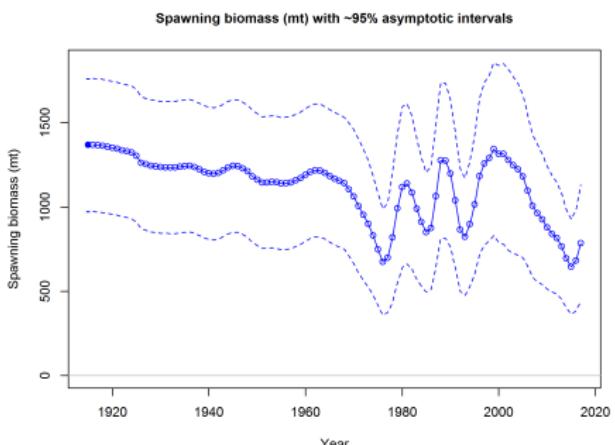
Natural mortality

- Prior based on maximum age of 21 (maximum observed age was 27, but fish older than 21 were rare in the available ages)
- Lognormal distribution with a median of 0.25714 (Hamel/Then prior)
- Base model fixes female natural mortality ($M = 0.25714$)
- Male M estimated as offset from female (male $M = 0.207733$)
- Sensitivities explore estimating M

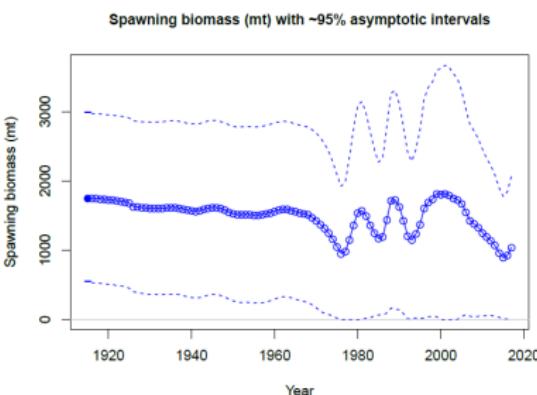
Natural mortality

Base model - fixed female M , male

M estimated as offset ($\ln R_0 = 8.16$,
depl. = 0.574, female $M = 0.25714$,
male $M = 0.2077$)

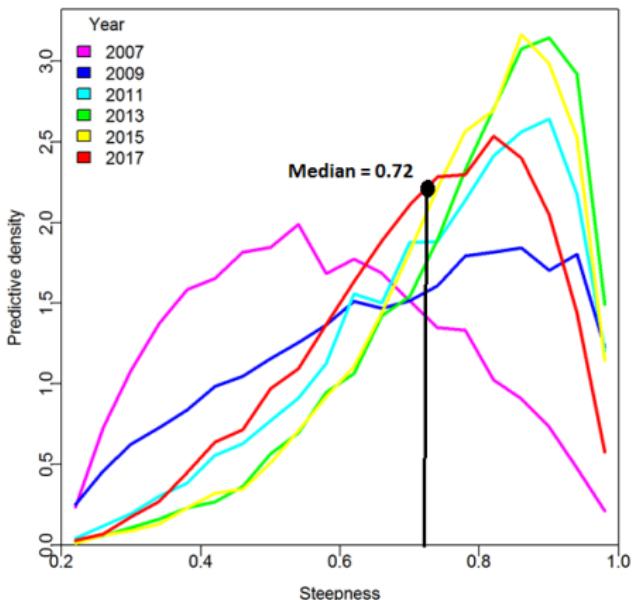


Base model with one M estimated
($\ln R_0 = 8.54$, depl. = 0.595, $M = 0.266$)



Steepness: Density-Dependent Recruitment Compensation

- Predictive distribution for Pacific rockfish meta-analysis
- Prior median in 2017 for steepness (h) = 0.718



Model Specifications

- Stock Synthesis version 3.30.05.04
- Model starts in 1916, unfished equilibrium catch prior to that
- Sex-specific growth and mortality with female M fixed at 0.2174
- Steepness fixed at 0.718 (from meta-analysis)
- Maximum age of 21
- One cm length bins
- Recruitment deviations estimated

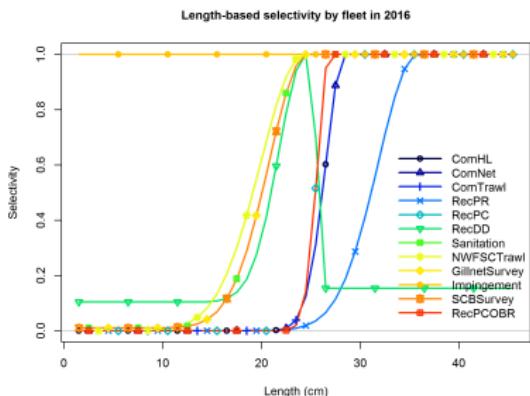


Selectivity

- Time blocks
 - Commercial fleet: 1916-1999 and 2000-2016 (10-in. minimum size limit as of 2000)
 - Recreational fleets: 1916-2000 (few regulations), 2001-2005 (fishery closures), 2006-2016 (consistent regulations)
- Double normal except for the impingement survey (Selectivity = 1.0 for all ages)
- Fisheries selectivity parameters estimated for commercial hook-and-line, recreational private, recreational party/charter, and recreational discard fleets

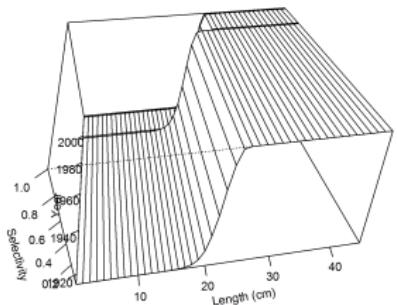
Selectivity

- Commercial gillnet and trawl fleets mirrored to the commercial hook-and-line fleet
- Recreational CPFV onboard observer retained catch mirrored to the recreational party/charter fleet selectivity (same boats)
- Survey selectivity parameters estimated for the POTW and NWFSC trawl surveys
- The gillnet survey and Bight trawl survey mirrored to the POTW selectivity

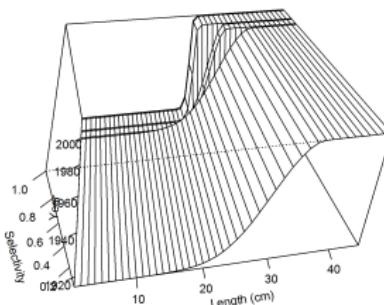


Selectivity

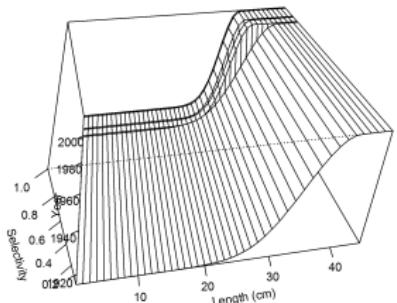
Female time-varying selectivity for ComHL



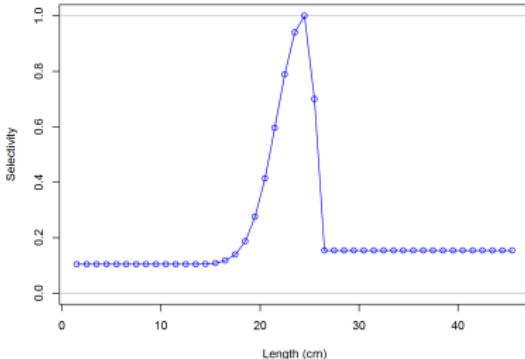
Female time-varying selectivity for RecPC



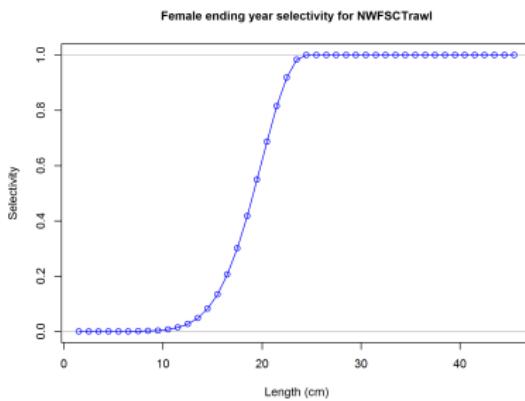
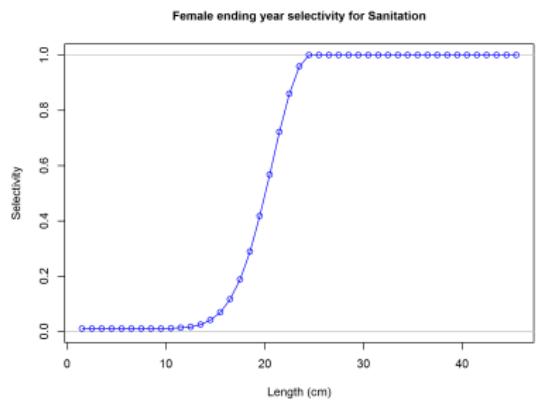
Female time-varying selectivity for RecPR



Female ending year selectivity for RecDD

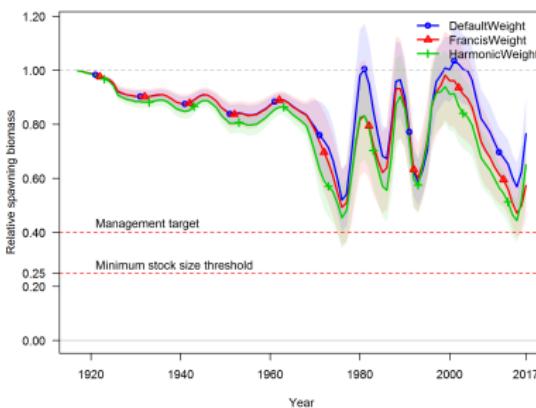
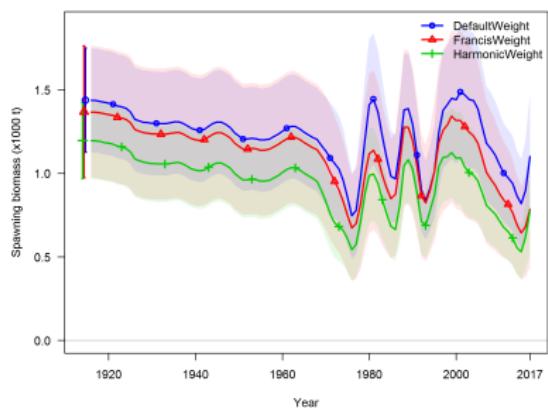


Gear Selectivity



Data Weighting

- Extra SD estimated for indices
- Francis weighting applied to length and age data
- Conducted sensitivities to no weighting and harmonic means



Convergence

- Confirmed that the Hessian was positive definite
- Final gradient is <0.0001
- Performed 50 trials using a 'jitter' to assess the model's ability to recover similar likelihood estimates when initialized from dispersed starting points
- The maximum difference in the likelihood from the jitter runs was 14.68 and 56% of runs were at the minimum likelihood

Pre-STAR Base Model Output

Year	Spawning biomass (mt)	~ 95% confidence interval	Estimated deple- tion	~ 95% confidence interval
2008	963.57	(555.81-1371.32)	0.70	(0.572-0.837)
2009	927.07	(539.76-1314.38)	0.68	(0.554-0.802)
2010	878.16	(513.26-1243.07)	0.64	(0.526-0.758)
2011	841.15	(494.98-1187.31)	0.61	(0.508-0.722)
2012	814.87	(483.41-1146.34)	0.60	(0.495-0.696)
2013	765.85	(451.39-1080.3)	0.56	(0.465-0.655)
2014	693.82	(401.18-986.46)	0.51	(0.417-0.598)
2015	644.49	(362.67-926.31)	0.47	(0.382-0.561)
2016	681.67	(382.78-980.56)	0.50	(0.399-0.597)
2017	785.33	(439.85-1130.8)	0.57	(0.455-0.694)

Pre-STAR Base Model Output

Year	OFL	ABC	ACL	ACT	Total Catch
2007	219		175		139.583
2008	219		175		103.887
2009	175		175		113.318
2010	155		155		105.968
2011	141	135	135		105.215
2012	132	126	126		120.008
2013	126	120	120		115.142
2014	122	117	117		123.822
2015	119	114	114		83.8908
2016	117	111	111		74.1613
2017	289	264	150	110	-
2018	278	254	150	110	-

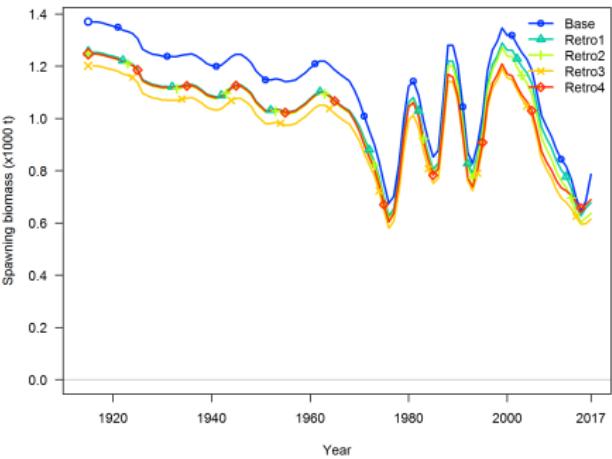
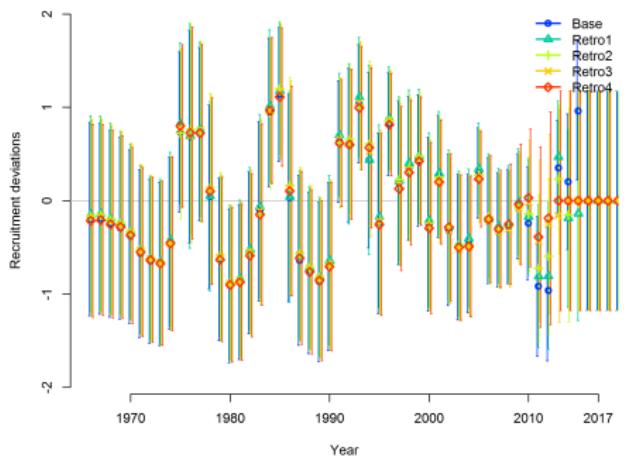
Pre-STAR Base Model Output

Switch to browser for r4SS output

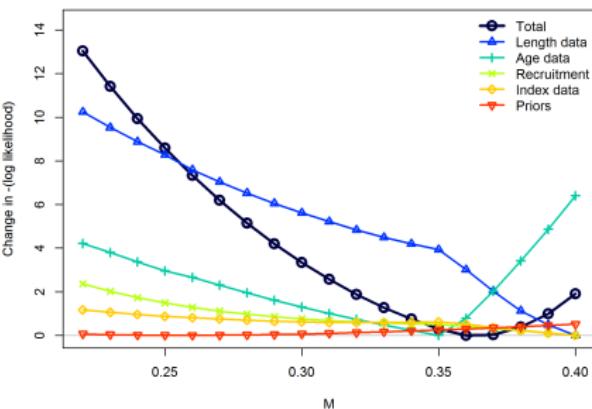
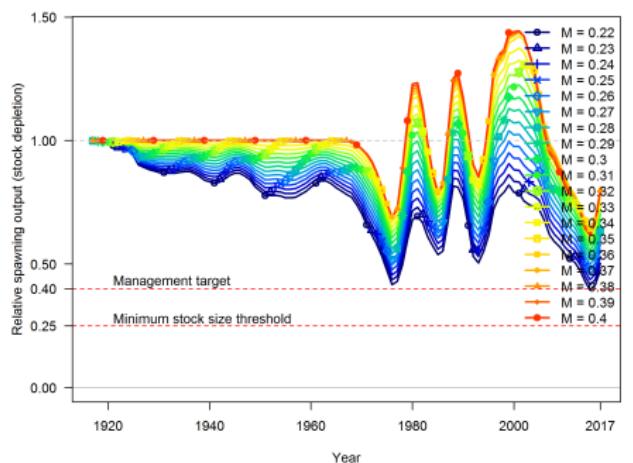


Retrospective Analysis

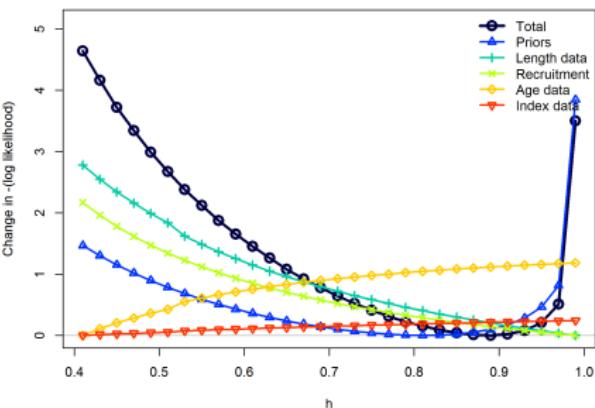
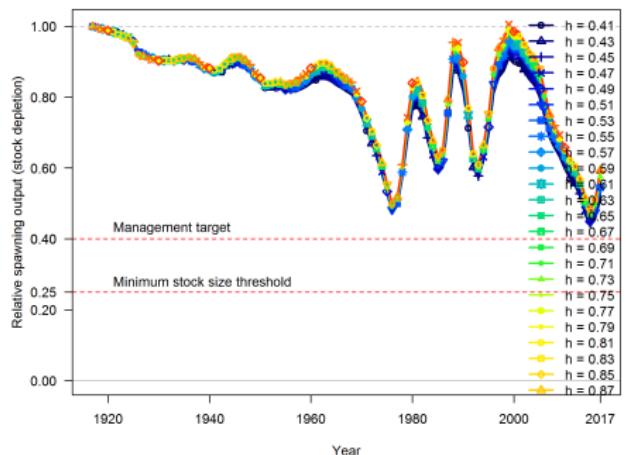
Retro1 = Remove one year; Retro2 = Remove last two years; etc.



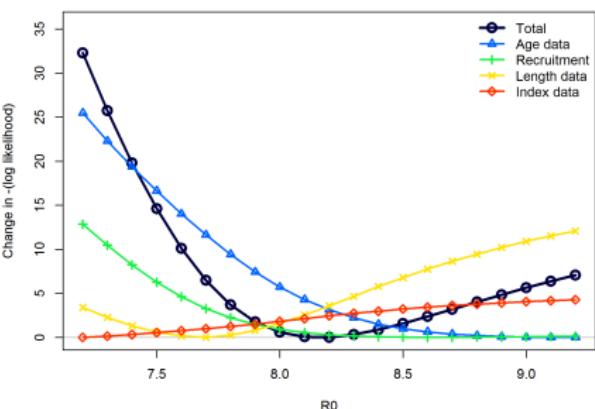
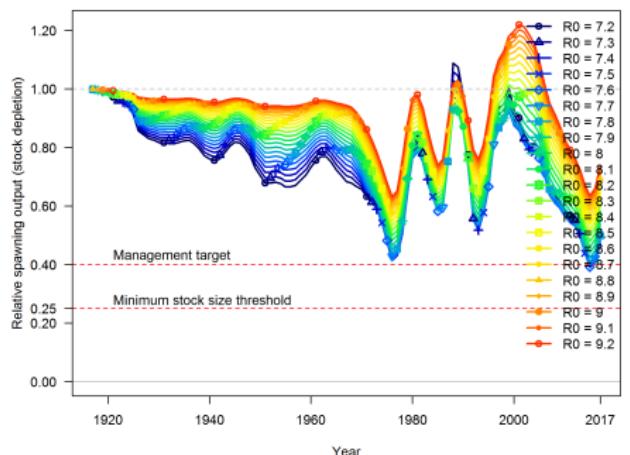
Likelihood Profiles - natural mortality



Likelihood Profiles - steepness



Likelihood Profiles - $\ln R_0$



Sensitivities

Sensitivities to Likelihood Components and Model Specification

Remove fleets, only one index, or length composition only

Sensitivity relative to the base model

Boxes are the 95% CI from the base model

Metrics

SB_0 Population scale

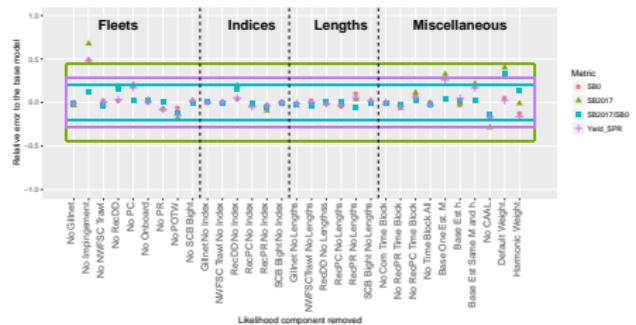
SB_{2017} Population scale

SB_{2017}/SB_0

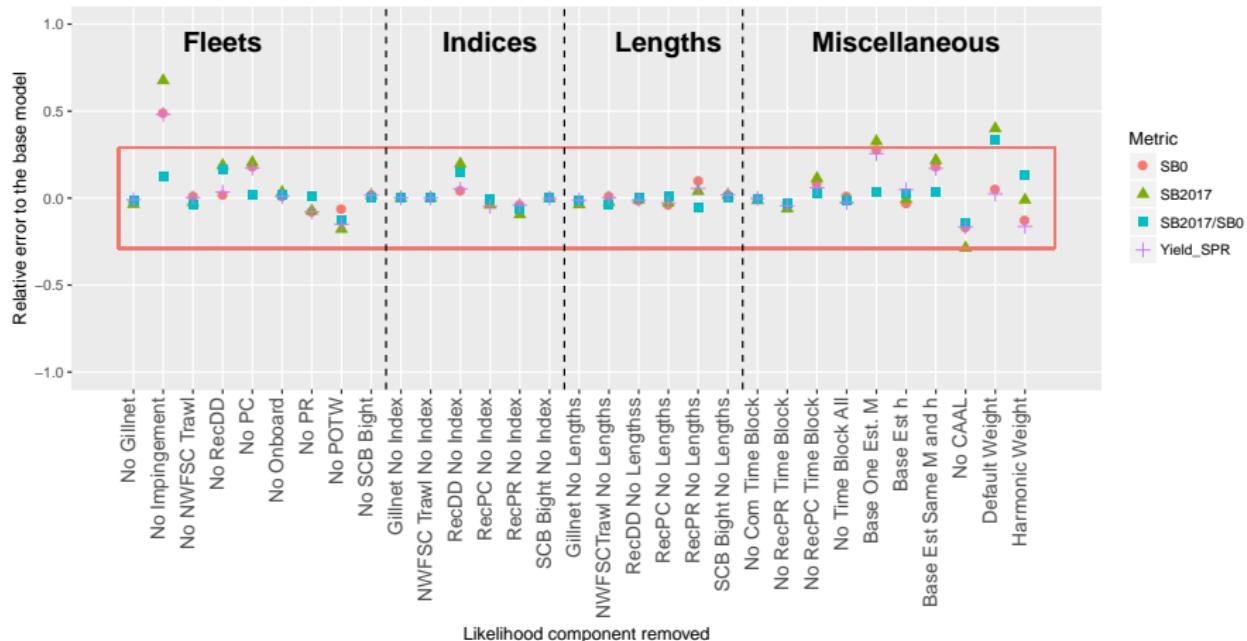
Depletion/Population status

$MSY_{SPR50\%}$

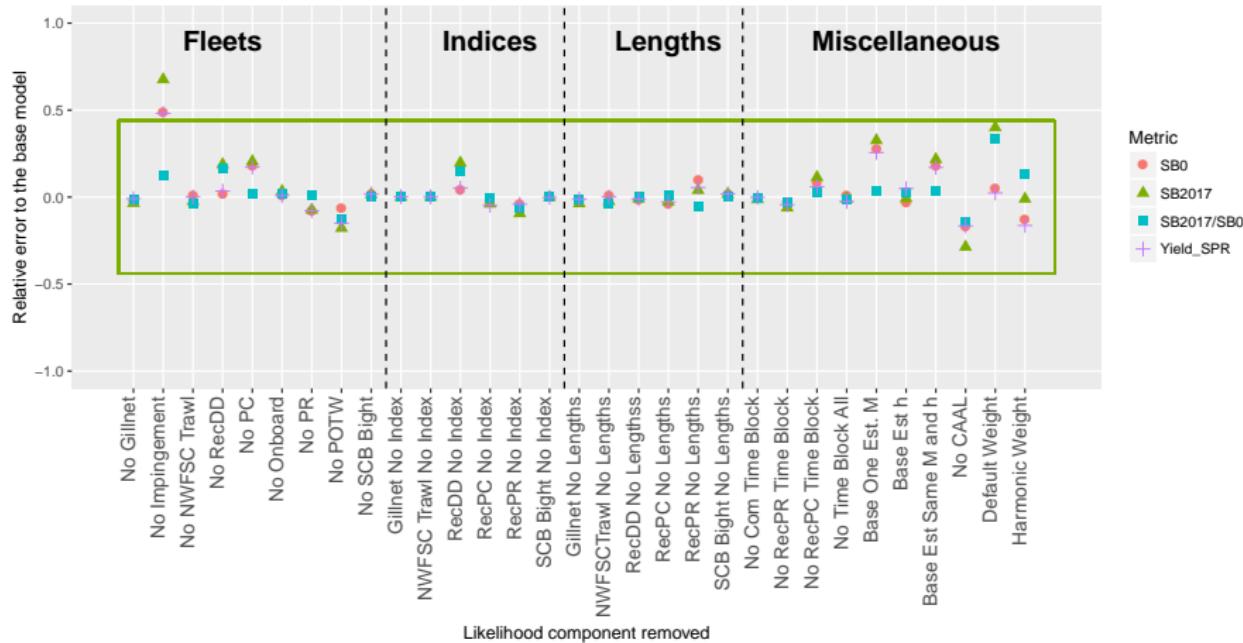
Yield/Productivity/scale



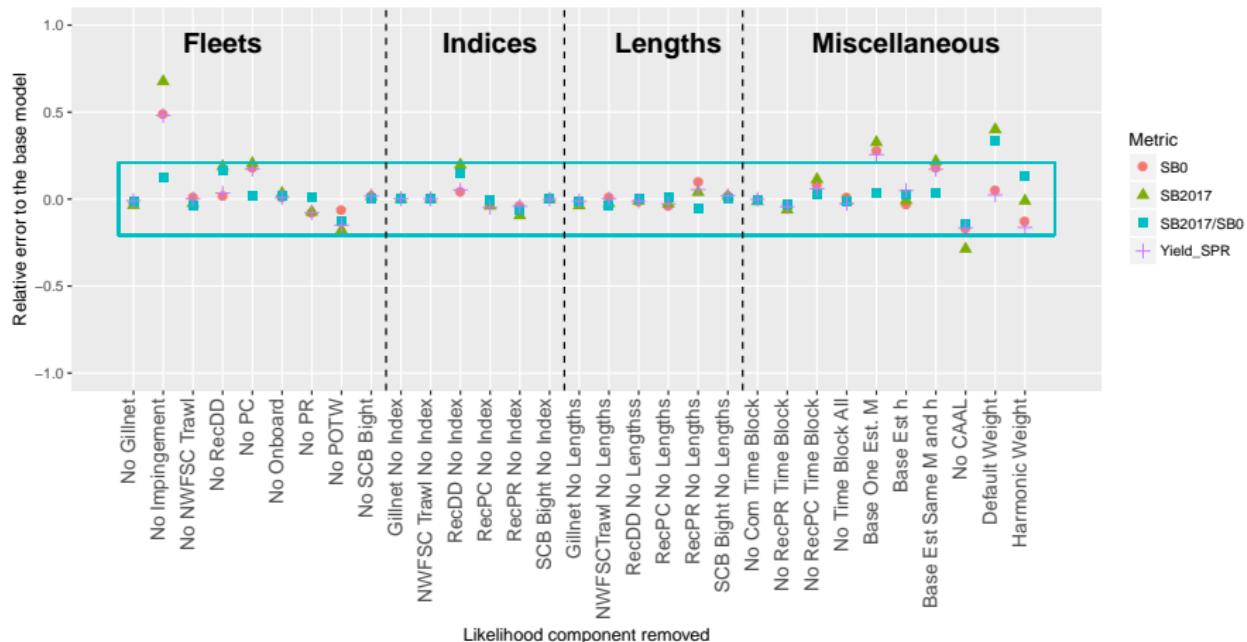
Sensitivities - SB_0



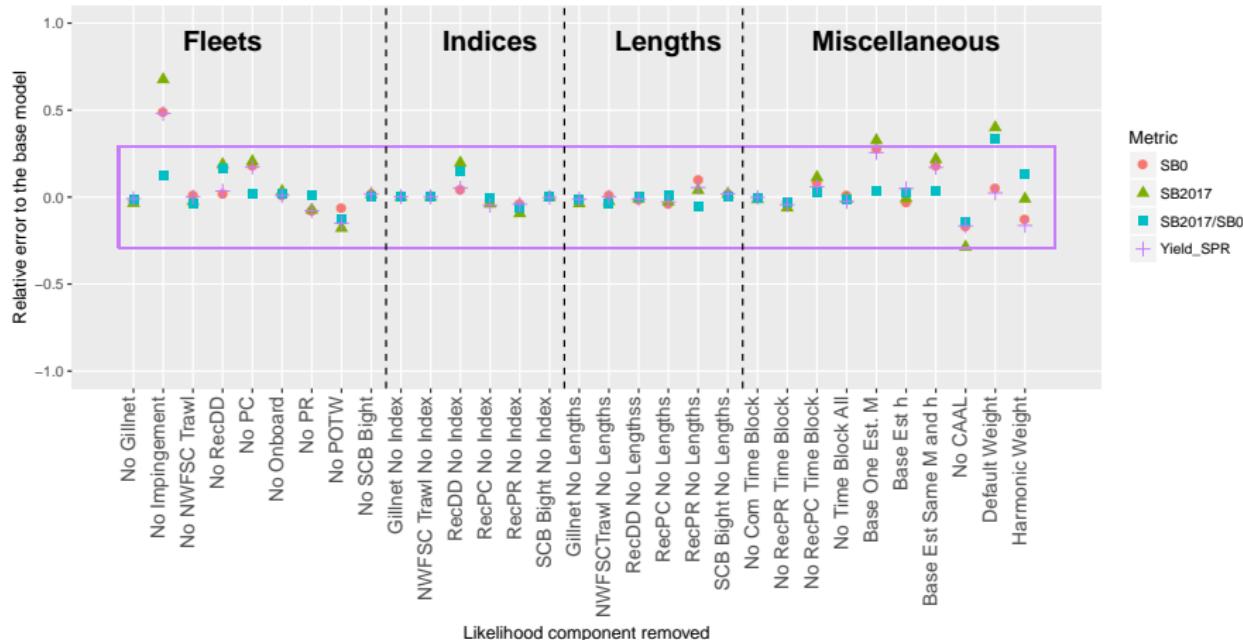
Sensitivities - SB₂₀₁₇



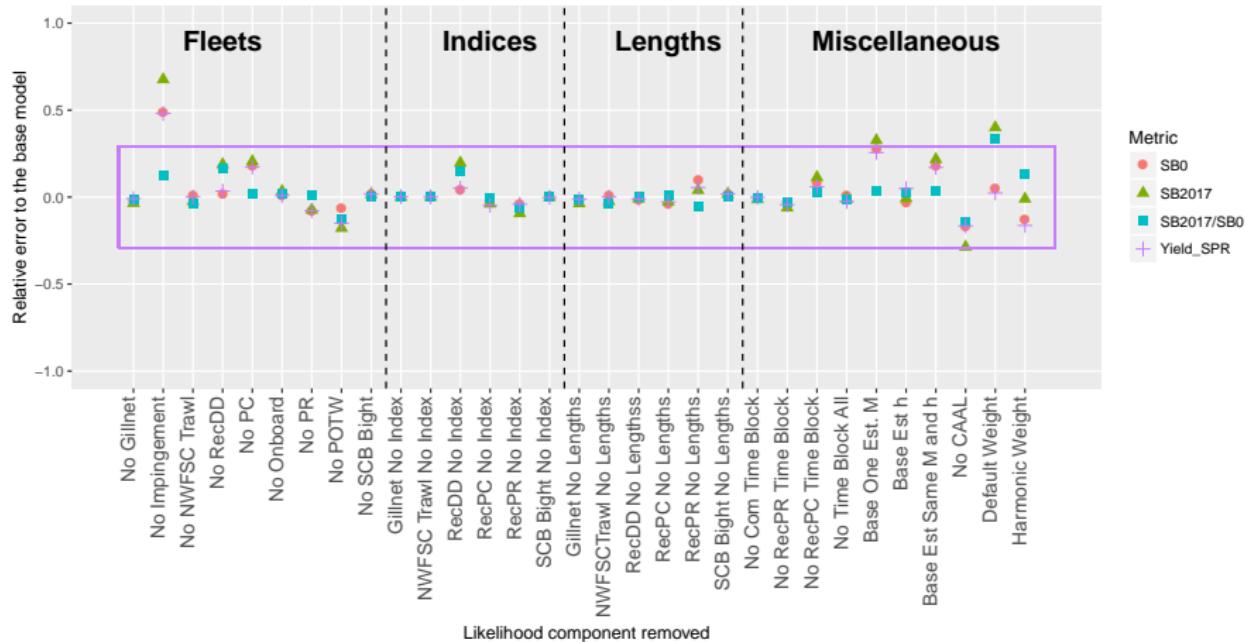
Sensitivities - Depletion



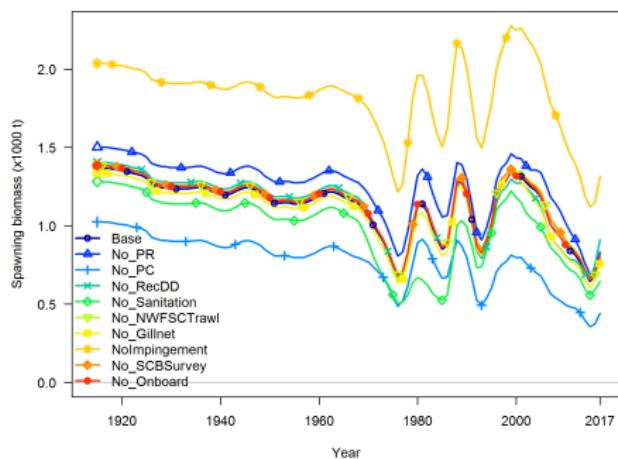
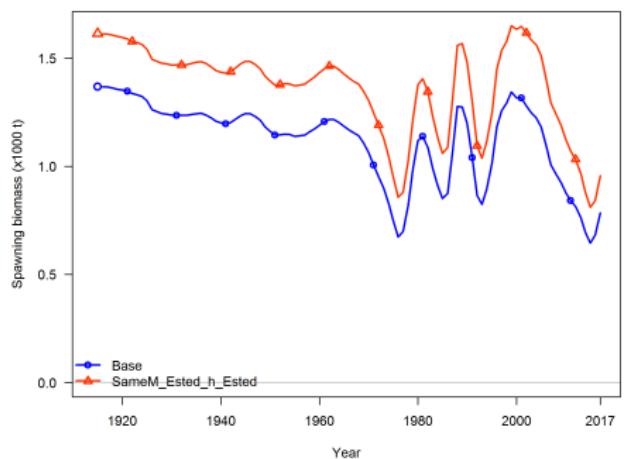
Sensitivities - Yield at $SPR_{50\%}$



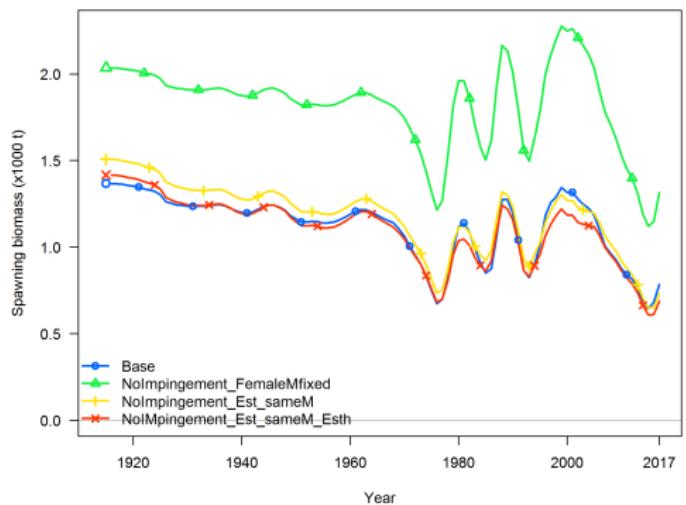
Sensitivities - All



Sensitivities

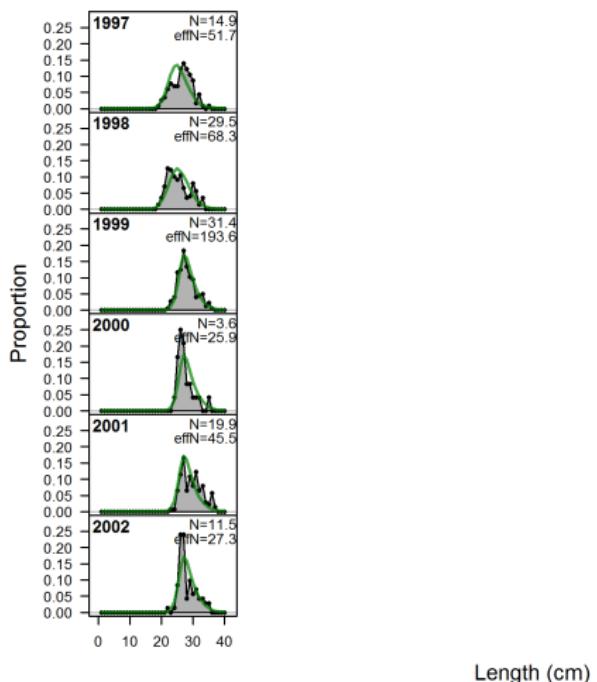


Sensitivities

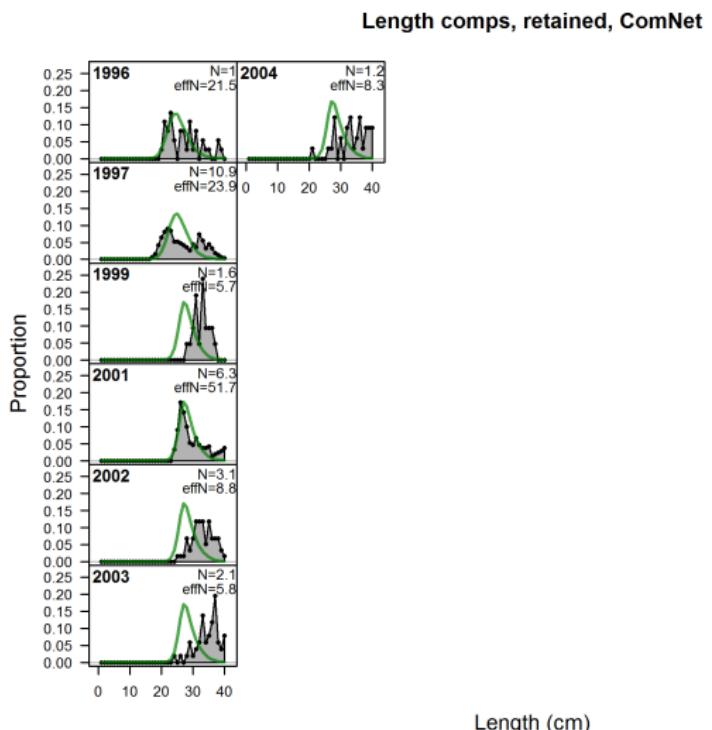


Length composition fits

Length comps, retained, ComHL

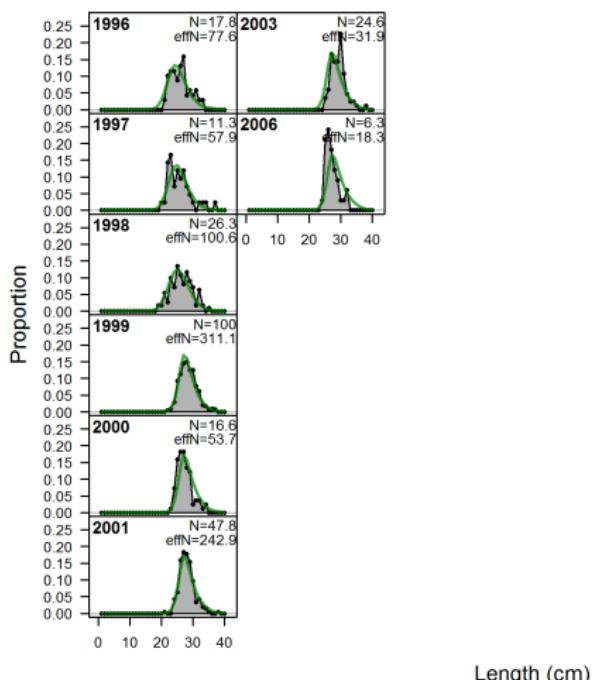


Length composition fits



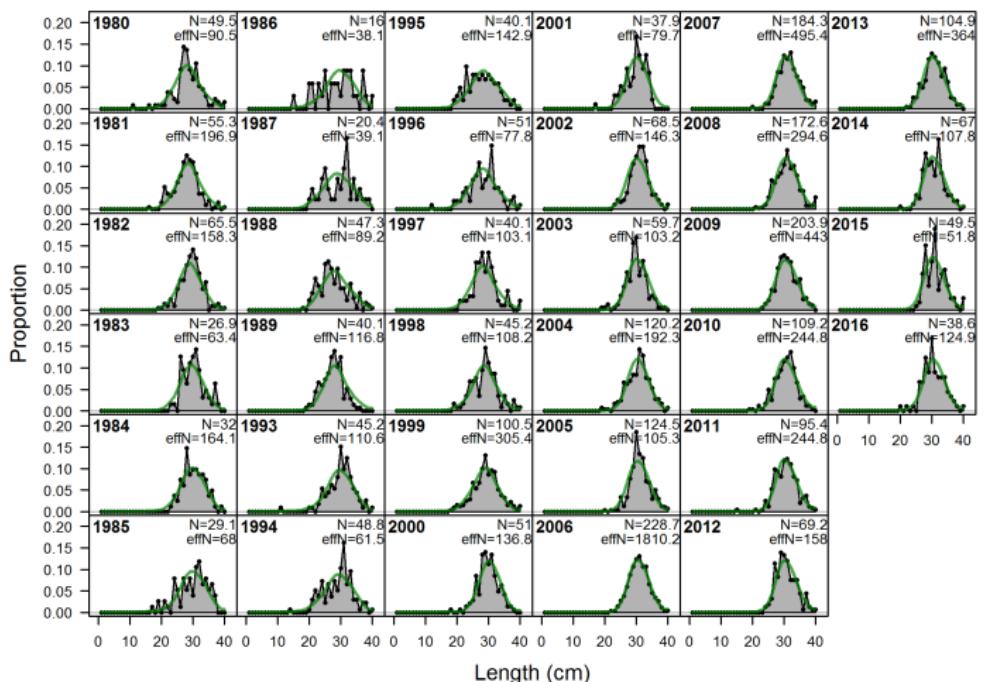
Length composition fits

Length comps, retained, ComTrawl



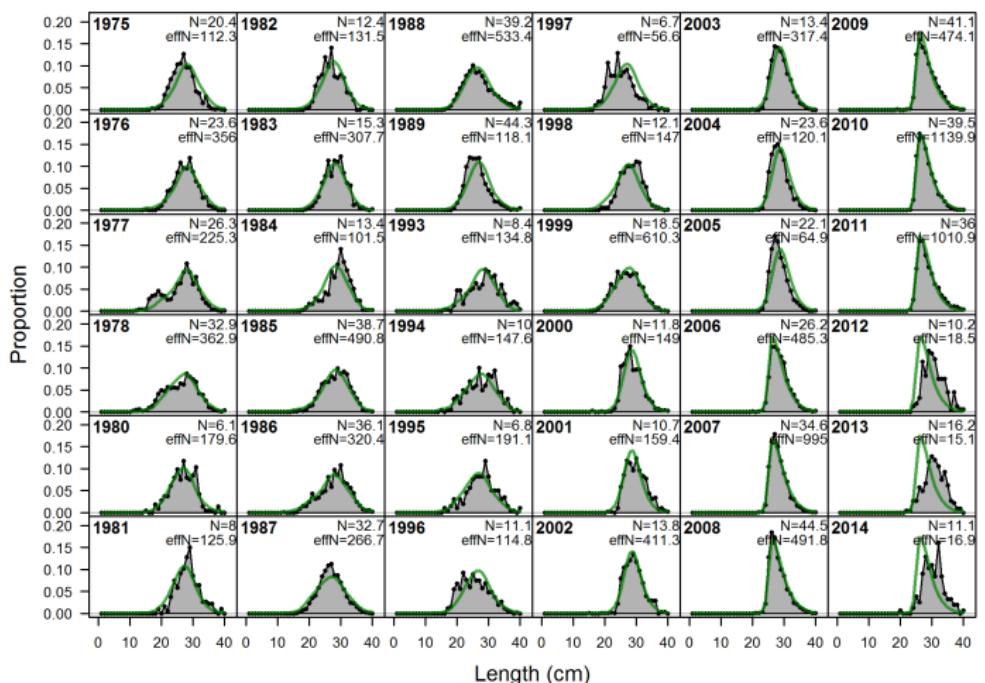
Length composition fits

Length comps, retained, RecPR



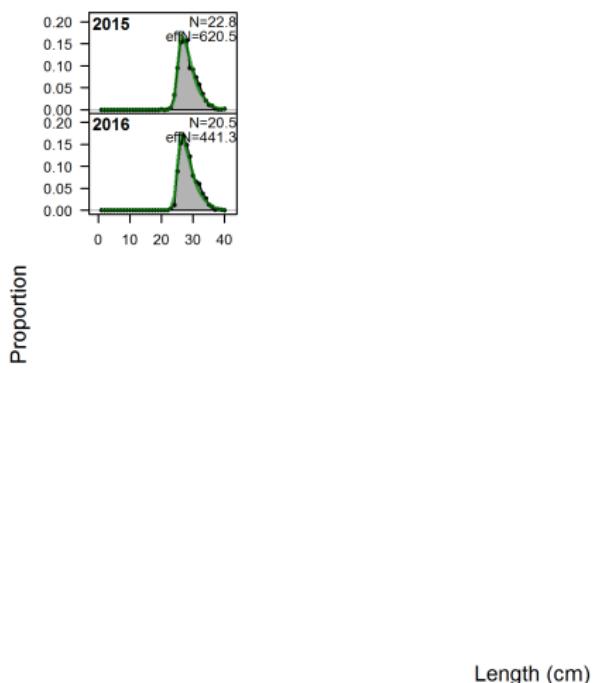
Length composition fits

Length comps, retained, RecPC



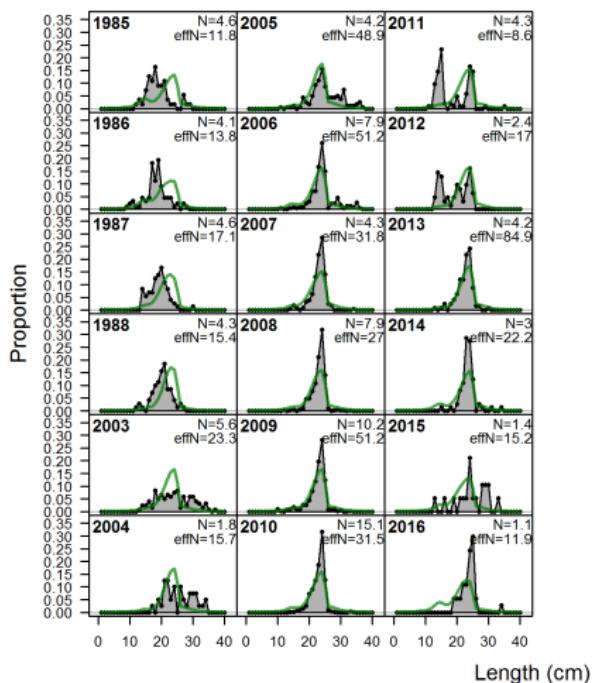
Length composition fits

Length comps, retained, RecPC



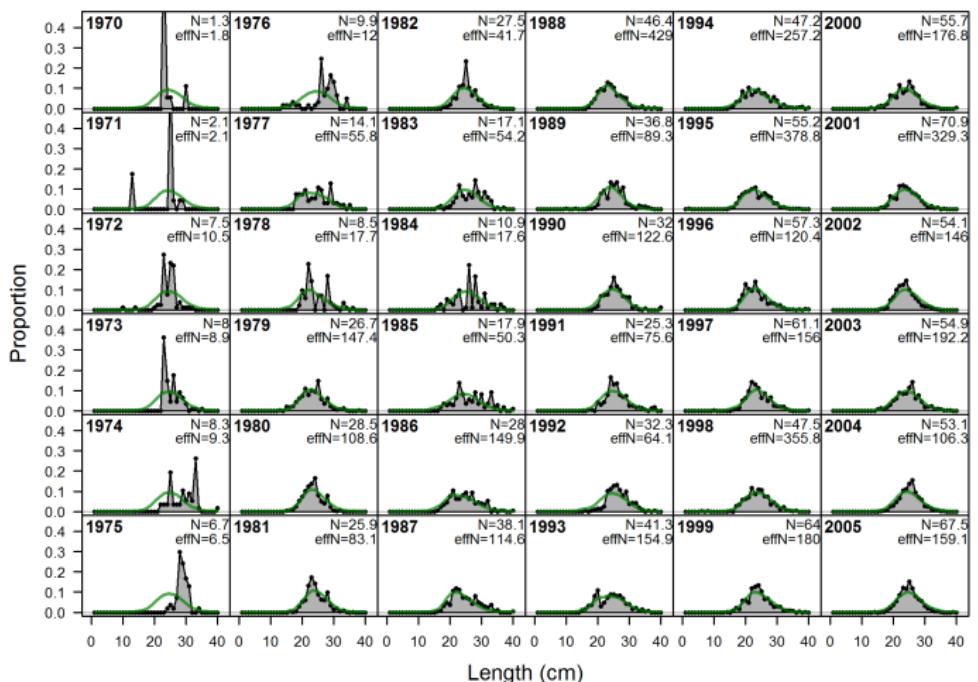
Length composition fits

Length comps, retained, RecDD



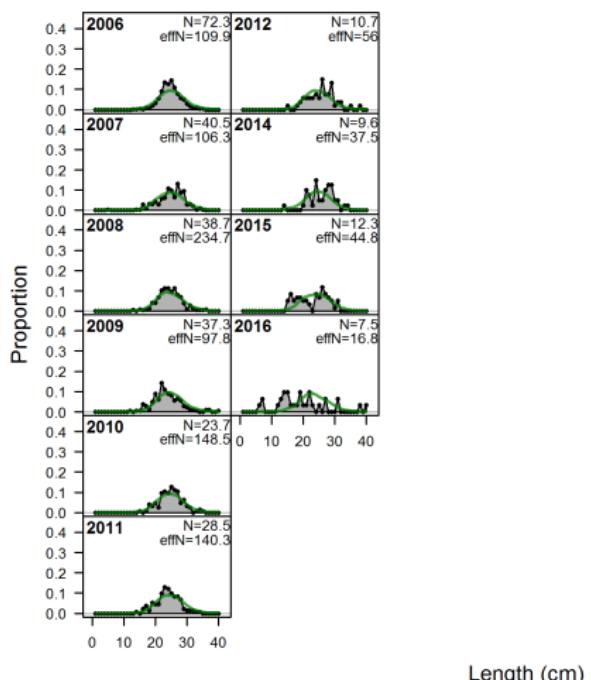
Length composition fits

Length comps, retained, Sanitation



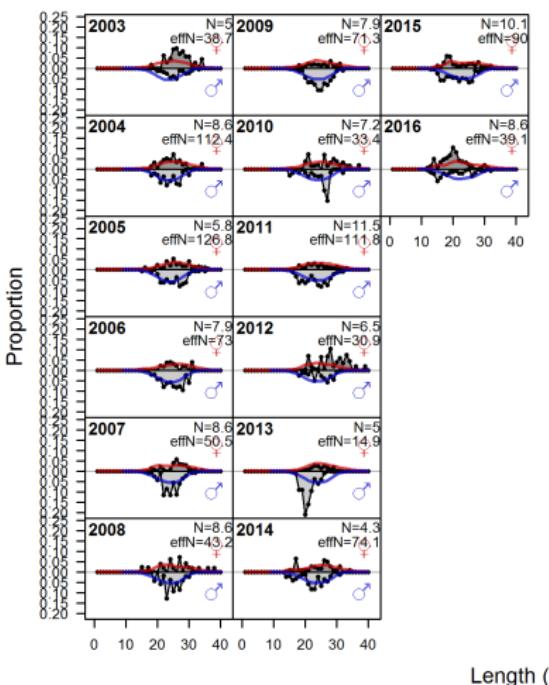
Length composition fits

Length comps, retained, Sanitation



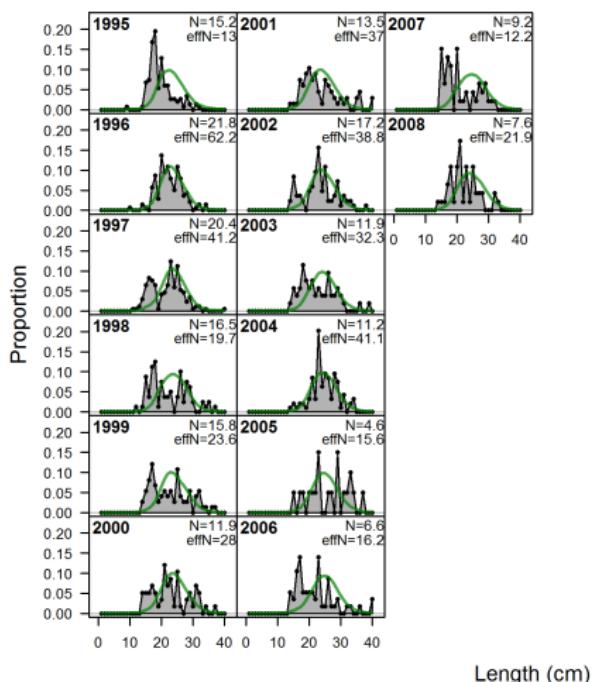
Length composition fits

Length comps, whole catch, NWFSC Trawl



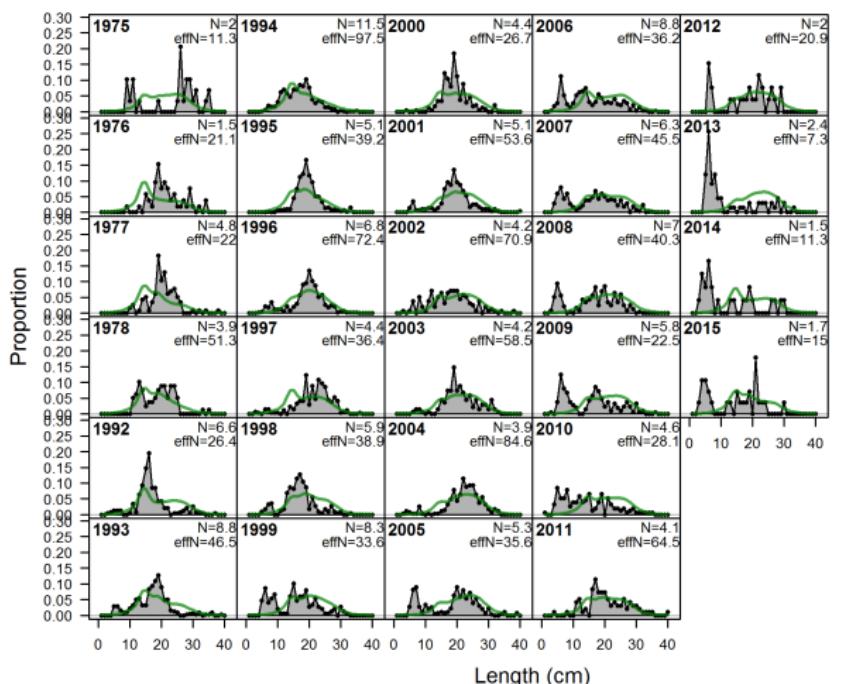
Length composition fits

Length comps, retained, GillnetSurvey



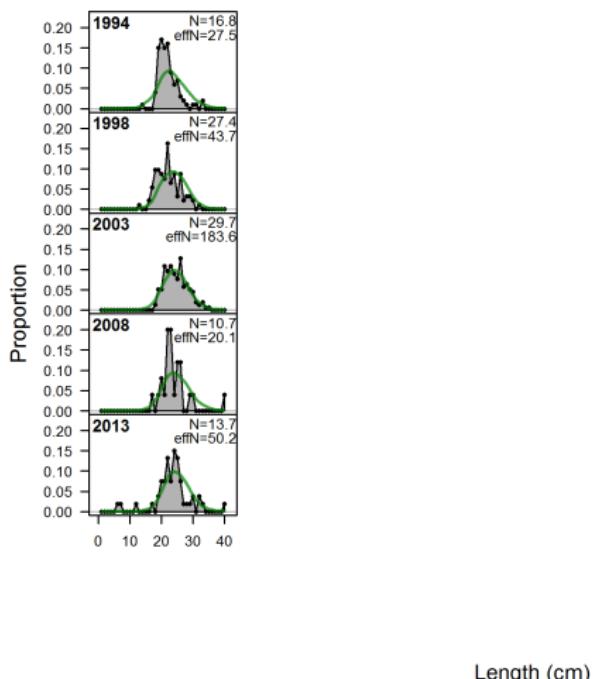
Length composition fits

Length comps, retained, Impingement

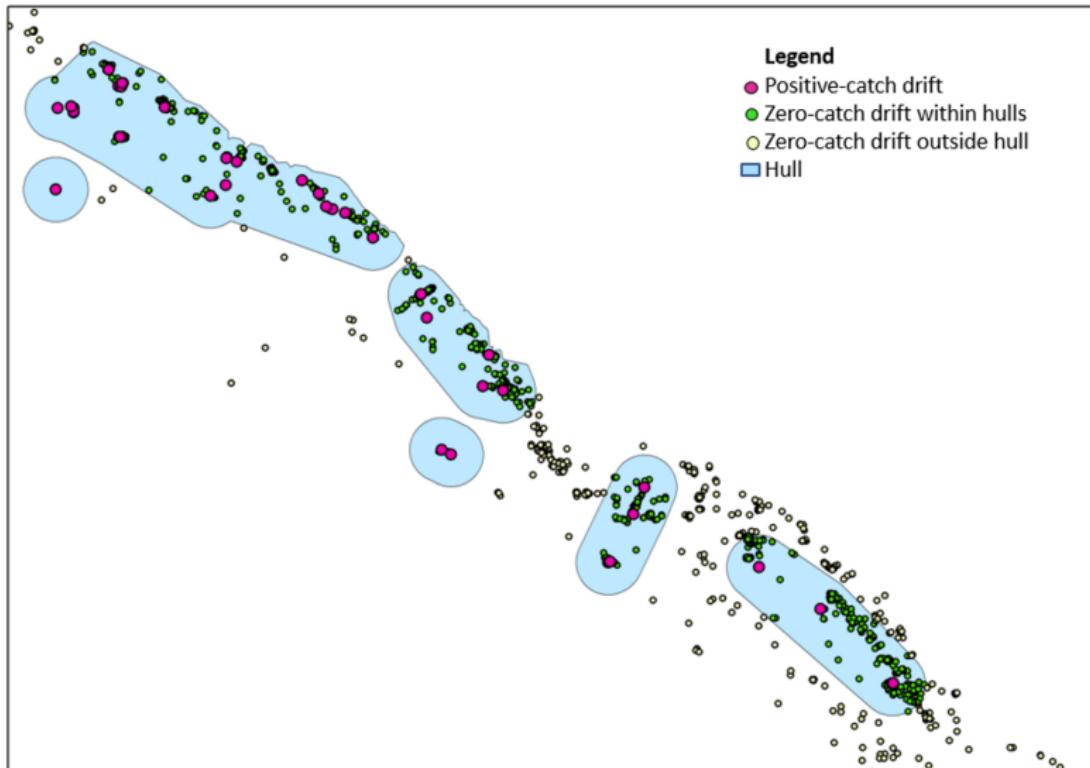


Length composition fits

Length comps, retained, SCBSurvey



Hull method (Onboard observer index)



VAST diagnostics

