Gray Triggerfish (*Balistes capriscus*) indices of relative abundance from SEAMAP Fall Plankton Surveys, 1986 to 2023

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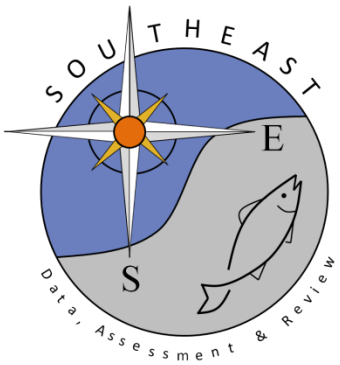

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Gray Triggerfish (*Balistes capriscus*) indices of relative abundance from SEAMAP Fall Plankton Surveys, 1986 to 2023

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Abstract: *The occurrence and abundance of gray triggerfish captured during Southeast Area Monitoring and Assessment Program (SEAMAP) ichthyoplankton resource surveys in the Gulf of America have been used to reflect trends in the relative spawning stock size of gray triggerfish since 2005. Estimates of annual relative abundance are based on larval and juvenile catch from SEAMAP Fall Plankton neuston net samples. SEAMAP ichthyoplankton surveys began to consistently document and quantify the amount of Sargassum collected in neuston samples in 2006. These samples were used to examine the association of larvae and juvenile gray triggerfish with Sargassum from these collections. The proportion of positive occurrence (PPOS) and catch (CPUE) of gray triggerfish were fount to be greatly dependent on the occurrence of Sargassum. Furthermore, the catch of gray triggerfish in neuston nets consists primarily (> 78%) of juvenile stages and not larvae which are typically used to index adult spawning stock. The standardized indices of gray triggerfish larval and juvenile of proportion of positive occurrence (PPOS) and catch per unit effort (CPUE) from neuston nets primarily represent the recruitment of juvenile fishes to Sargassum habitat and not spawning stock biomass. Therefore, it is recommended to not incorporate the SEAMAP Fall Plankton Survey standardized indices of gray triggerfish into the assessment model.*

Introduction

The Southeast Area Monitoring and Assessment Program (SEAMAP) has supported the collection and analysis of ichthyoplankton samples from resource surveys in the Gulf of America since 1982 with the goal of producing a long-term database on the early life stages of fishes. Occurrence and abundance of larval and juvenile gray triggerfish captured during these surveys were initially reviewed as a potential source of fishery-independent data to reflect trends in the relative spawning stock size of gray triggerfish during the Southeast Data Assessment and Review (SEDAR9) process in 2005 (Lyczkowski-Shultz et al., 2005 and SEDAR9, 2006). Examinations of nominal proportion of positive occurrence and mean abundance of gray triggerfish larvae and juveniles indicated they consistently occurred most frequently and in highest abundance from neuston net samples collected during the annual SEAMAP Fall Plankton survey conducted primarily during late August and September. Therefore, the recommendation was made to develop indices of larval and juvenile catches of gray triggerfish from neuston samples collected during this time series.

The initial index developed for SEDAR9 was based on the 1986 to 2002 Fall Plankton time series and methods utilized are documented in SEDAR9 Assessment Report 1 (SEDAR, 2006). In 2011,

the index was updated for the SEDAR9 Update Assessment utilizing the same methods to extend the time series through 2007 (SEDAR9, 2011). The larval/juvenile index was not updated for SEDAR43 in 2014/2015 due to a backlog of unidentified balistid and monacanthid larvae and juveniles from SEAMAP plankton samples. However, the SEDAR9 Update index (1986 to 2007) was incorporated into the SEDAR43 assessment model (SEDAR43, 2015). The index was reviewed and last updated for the SEDAR62 Data Workshop (Hanisko *et al.*, 2019).

This document outlines the development of gray triggerfish larval/juvenile indices for the continental shelf of the entire U.S Gulf of America, and for its west and east regions. The regional indices of abundance follow the spatial breakdown per the SEDAR 100 terms of reference. Indices are based on similar methods as outlined for the SEDAR62 assessment. Additionally, we examine the association of gray triggerfish larvae and in-situ Sargassum using samples collected from 2006 to 2022. Currently, the time series of data from the Fall Plankton survey available for analysis extends from 1986 to 2023. Larval and juvenile triggerfish specimens from the 2024 survey have not been cataloged, and have yet to be processed through identification protocols.

Methodology

SEAMAP Plankton Sample Methodologies

The standard sampling gear and methods used to collect plankton samples during SEAMAP surveys is similar to those recommended by Kramer et al. (1972), Smith and Richardson (1977) and Posgay and Marak (1980). A single or double 2x1 m pipe frame neuston net fitted with 0.947 (0.950) mm mesh netting is towed at the surface with the frame half submerged for a targeted tow time of 10 minutes. Nets are then retrieved and the sample rinsed into the net's cod end. The samples are condensed and preserved initially in 10% formalin or 95% ethanol. Samples are then transferred to fresh 95% ethanol within 24 to 48 hours. Small adult fish and invertebrates that can easily fit in the sample jar are preserved in the sample. Larger fish are allowed to be discarded if identifications and sizes are noted on data sheets or in digital comments (Rester, 2016). Catches of larvae and juveniles from neuston nets are standardized to account for sampling effort and expressed as number of fish per 10 min tow.

Sample Processing and Identification of Gray Triggerfish

Initial processing of most SEAMAP plankton samples has been carried out at the Sea Fisheries Institute, Plankton Sorting and Identification Center (ZSIOP), in Szczecin, Poland, under a Joint Studies Agreement with National Marine Fisheries Service (NMFS). Larvae and juveniles were removed from neuston net samples and identified to the lowest possible taxon, which in most cases was the family level. Body length (BL) in mm was measured and recorded for a subsample of specimens in each sample.

Triggerfish larvae are distinctive and can be identified at the smallest sizes found in plankton

collections, i.e. ~2 mm. Larval development of gray triggerfish was first described by Matsuura and Katsuragawa (1981). Lyczkowski-Shultz and Ingram (2003) described distinguishing characteristics that allow the larvae of five of the six species of triggerfishes found in the Gulf of America to be identified. Only *Balistes vetula* larvae remain undescribed. All specimens of gray triggerfish used in these analyses were re-examined by ichthyoplankton specialists at the Southeast Fisheries Science Center, Mississippi Laboratories. Identification to species level was accomplished using descriptions in Lyczkowski-Shultz and Ingram (2003). Length at transformation from larval to juvenile occurs at 10mm.

Sample Selection

The SEAMAP Fall Plankton Survey area covers the northern GOM from the 10 m isobath out to the continental shelf edge within the U.S. EEZ, and originally comprised approximately 132 designated sampling sites i.e. 'SEAMAP' stations. Beginning in 1999 and continuing to the present, samples have been taken at 11 additional SEAMAP stations located off the continental shelf in the western Gulf of America during the survey. Most stations are located at 30-nautical mile or 0.5^{o} (~56 km) intervals in a fixed, systematic, 2-dimensional (latitude-longitude) grid of transects across the Gulf of America. Some SEAMAP stations are located at < 56 km intervals especially along the continental shelf edge, while others have been moved to avoid obstructions, navigational hazards or shallow water.

The intended sample design for SEAMAP surveys calls for a single neuston sample to be taken at each site (SEAMAP station) in the systematic grid. However, over the years additional samples have been taken using SEAMAP gear and collection methods at locations other than designated SEAMAP stations. Some locations were also sampled more than once during a survey year. In instances where more than one sample was taken at a SEAMAP station, the sample closest to the central position of the systematic grid location was selected for inclusion in the data set. When SEAMAP stations were sampled by more than one vessel during the survey, priority was given to samples taken by the NMFS (and not the state) vessel.

Spatial coverage of the Fall Plankton Survey from 1986 to 2023 has at times been impacted due to severe weather, vessel break downs, time or other constraints (Appendix Figure 1). Sampling for both the western (> 89.25° West Longitude) and eastern (< 89.25° West Longitude) Gulf of America was severely curtailed or cancelled due to tropical storms in 1998, 2005, 2008 and 2024, mechanical issues in 2015, COVID 19 in 2020 and tropical weather and mechanical issues in 2023. Spatial coverage in the western Gulf of America has been consistent over the time series with the exception of these years. In the eastern Gulf of America, spatial coverage has been considerably more variable. Curtailed neuston sampling during the 1992, 2004, 2017 and 2021 surveys resulted in large portions of the eastern Gulf of America remaining un-sampled. Much of the spatial variability in the eastern Gulf of America stems from the typical west to east progression of the survey. Due to this progression, any reduction in survey time often limits sampling effort in the southern (Tampa, FL to Key West, FL) portion of the survey area.

Year to year variability in spatial coverage during the Fall Plankton Survey is addressed by limiting observations to samples taken at SEAMAP stations that were sampled during at least 66% of all years for which there was consistent spatial coverage respectively for the entire Gulf of America, west and east regions (Figure 1). Based on this protocol, the core data of the Gulf of America index includes all samples taken during at least 19 of the 28 years of available data with the years 1992, 1998, 2004, 2005, 2008, 2015, 2017, 2021 and 2023 excluded. The core data of west index includes all samples taken during at least 21 of the 32 years of available data with the years 1998, 2005, 2008, 2015, and 2023 excluded. In the east, the core data of the index includes all samples taken during at least 19 of 29 years of available data with the years 1992, 1998, 2004, 2005, 2008, 2015, 2017 and 2021 excluded. Spatial coverage during the 2024 survey will potentially extend the west index through 2024 once gray triggerfish specimens are processed through identification protocols.

Adjustments to Catch to Account for Discarded Fish

Counts and measurements of fishes discarded from SEAMAP neuston net samples are not recorded in identifications and length measurements of processed samples. A review of digital comments archived with the dataset found only a small subset of records (~25) from all SEAMAP plankton surveys regarding the presence of gray triggerfish juveniles and small adults in samples. Most noted the presence of gray triggerfish in samples, with at least 10 records indicating removal of fish with recorded lengths. These counts and measurements of removed gray triggerfish identified in comments were added to the analytical dataset. In nearly all cases, gray triggerfish removed from samples were greater than 50 mm. There is concern that the recording of removed fish in digital records was not consistent over the time series, especially prior to 1995. However, the concern is mitigated by the rarity of the events and that over 95% of larvae and juveniles captured in neuston nets are less than 45 mm. Examinations of nominal annual proportion positive and CPUE based only on specimens of gray triggerfish less than 45 mm indicated similar trends to those utilizing all lengths. Therefore, even in the event that the removed gray triggerfish were not recorded in the comments there should be minimal impact on the relative indices of abundance.

Index Construction

Generalized linear modeling (GLM) methods were used to estimate the proportion of positive occurrence (PPOS) and relative catch per unit effort (CPUE) of larval and juvenile gray triggerfish in neuston nets. PPOS was modeled utilizing a binomial distribution with a logit link. CPUE was estimated by a log linked negative binomial model based on counts of larvae with effort (minutes fished) as an offset. The factors Year, Time of Day (TOD), Region and Depth were examined as possible influences on PPOS and CPUE (Table 1). All models were built using a backward selection procedure based on type 3 analyses with an inclusion level of significance of $\alpha = 0.05$. The Year effect is integral to the calculation of annual estimates and is forced into the standardization procedure regardless of significance. Years with zero catch are not included

in the models. Binomial PPOS model performance was evaluated using AIC, while the performance of the negative binomial CPUE were evaluated based on the examination of residual scatter and QQ plots in addition to AIC. QQ and residual scatterplots for the negative binomial models were assessed using randomized quantile residuals (Dunn and Smyth, 1996).

Results and Discussion

Distribution, Abundance and Size at Capture

A total of 997 gray triggerfish larvae and juveniles were captured in 3,158 neuston net samples (Gulf of America index samples only) during 28 Fall Plankton Surveys from 1986-2022. Gray triggerfish were taken in 11.6 % (0.01 SE) of samples with a mean CPUE of 0.35 (0.06 SE) fish per 10 min tow (Table 2). They were captured throughout the survey area but occurred 1.9 times more often and at 1.9 times greater CPUE in the western than in the eastern Gulf of America (Table 2 and Figure 2). Catches of gray triggerfish varied by time of day (Table 3). CPUE of gray triggerfish larvae and juveniles was 1.7 times higher during the morning and evening crepuscular periods than during the day with larvae taken 1.6 times more often. However, the mean CPUE of gray triggerfish during the crepuscular period was 0.7 times that of CPUE at night with larvae taken 1.1 times as often. Larvae were captured over station depths ranging from 9 to 427 m with a mean station depth of 89 m and a median station depth of 71 m.

Length data was available for 961 gray triggerfish larvae and juveniles taken in index samples. Captured fish ranged from 1.9 to 79.5 mm in body length (BL) with a mean BL of 18.4 mm and a median BL of 15.2 mm (Figure 3). Ninety-five percent of gray triggerfish in neuston net samples were less than 49 mm BL. Juvenile stages accounted for 78.7 % of gray triggerfish taken in neuston net samples based on a size at transformation of 10 mm BL. Length frequencies indicate a bimodal pattern with a separation occurring around 5 mm BL. The 5 mm BL length coincides well with complete fin development between 3.0 and 6.2 mm BL (Lyczkowski-Shultz and Ingram, 2003).

Larval and Juvenile Gray Triggerfish and Sargassum

SEAMAP ichthyoplankton surveys began to consistently document and quantify the amount of *Sargassum* collected in neuston samples since 2006. Samples (n = 1,326) taken during 2006 to 2022 (Gulf of America index samples only) were used to examine the relationship between catches of gray triggerfish and *Sargassum* collected in neuston nets. *Sargassum* was encountered in 0.39 (0.01 SE) of samples. CPUE (liters/ 10 min tow) of *Sargassum* averaged 1.56 (0.230 SE) and ranged from 0 to 143.83. Gray triggerfish larvae and juveniles were encountered in 0.106 (0.008 SE) of samples with an average CPUE of 0.392 (0.121 SE) fish. The PPOS and CPUE of gray triggerfish from samples (n = 517) with *Sargassum* present were 0.19 (0.02 SE) and 0.84 (0.31 SE) respectively.

Examination of gray triggerfish lengths (n = 368) from the 2006 to 2022 samples with *Sargassum* indicated that larvae at or below 5 mm BL were more likely encountered in neuston tows where little (less than 1 liter) or no *Sargassum* was recorded (Figure 4). In contrast, larvae and juveniles larger than 5 mm BL are encountered primarily when more than 1 liter of *Sargassum* is collected in samples. Samples (n = 23) with positive catches of gray triggerfish at 5 mm BL or less had a PPOS of *Sargassum* of 0.22 (0.09 SE), whereas samples (n = 131) with positive catches of fish greater than 5 mm BL had a PPOS of *Sargassum* of 0.78 (0.04 SE). The overall PPOS of gray triggerfish at 5 mm BL or less from all samples (n = 1,326) was 0.02 and the PPOS for fish greater than 5 mm BL was 0.09.

The CPUE (fish / 10 min tow) of gray triggerfish from Gulf of America index samples (n = 3,158) varied by three orders of magnitude among samples (n = 365) in which they were present. The CPUE of positive samples ranged from 0.85 to 148.01 with a median of 1.00, a 95% quantile of 7.98 and a 99% quantile of 24.25 (Figure 5). The four CPUE values at or above the 99th quantile ranged from 27.00 to 148.01. These values accounted for 24.8% of the summed total abundance over the time series of observations, with the maximum CPUE value alone accounting for 13.5% of the total. The maximum CPUE value was observed in 2022 and represents a value 2.7 greater the next highest CPUE of 55.30 observed in 2002. The extreme values from 2007 and 2022 fall into the time range for which we can examine CPUE values with respect to *Sargassum* PPOS and CPUE (Figure 6). Both observations consist of larvae and juveniles greater than 5 mm BL, and were also associated with higher *Sargassum* CPUE. In the case of the 2022 observation, it was associated with the highest *Sargassum* CPUE of the time series. However, a clear pattern of increasing gray triggerfish CPUE with increasing *Sargassum* CPUE for fish greater than 5 mm BL is not apparent (Figure 7).

Indices of Abundance

Preliminary gray triggerfish nominal PPOS and CPUE indices and GLM based binomial PPOS and negative binomial CPUE standardized indices were generated from Gulf of America index samples to establish initial trends (Figures 8, Tables 4 and 5). Factors retained in the binomial and negative binomial model to generate standardized indices are show in Table 6, and residual diagnostic plots for the negative binomial models in Figure 9.

Annual estimates of Gulf of America nominal PPOS and CPUE (Pearson's r = 0.44) and standardized PPOS and CPUE (Pearon's r = 0.52) were only moderately correlated (Figures 6 and 8). In contrast, the SEDAR 62 standardized PPOS and CPUE (Pearson's r = 0.78) indices were highly correlated (Hanisko *et al.*, 2019). The primary difference between the SEDAR 62 and preliminary SEDAR 100 indices is the inclusion of observations from 2000, 2002 and the extension of the time series from 2016 to 2022. The inclusion of these years incorporates three of the four identified extreme observations. High divergence between annual PPOS and CPUE estimates for the years with extreme observations was clearly evident (Figures 6 and 8). In order examine the effects of the extreme observations on the indices, we set them to the 99th

quantile (24.25) of positive CPUE values and the negative binomial model rerun. Reducing the influence of these observations resulted in high correlation (Pearson's r = 0.81) between the binomial PPOS and negative binomial CPUE annual estimates (Figure 8).

Indexing the relative abundance of gray triggerfish from neuston net collections is complicated by their unique early life history. Larvae hatch from demersal nests, become pelagic and remain in the plankton from four to seven months (Dooley 1972; Richards & Lindeman 1987). Floating *Sargassum spp.* provides habitat and refuge for young fish species (Kingsford 1995, Casazza & Ross 2008, Ballard & Rakocinski 2012). In the Gulf of America, gray triggerfish are one of the most abundant species associated with floating *Sargassum* spp. (Bortone et al. 1977, Wells & Rooker 2004). The consistent associations young gray triggerfish with *Sargassum* suggesting that circulation patterns of *Sargassum* may determine dispersal and distribution patterns (Ingram 2001). In this way, young gray triggerfish may rely on *Sargassum* as, not only a method to deliver them to suitable adult habitat, but provide a refuge until that habitat is encountered. A major unanswered question is whether or not the association is obligate or facultative.

The catch of gray triggerfish in SEAMAP neuston nets are dominated by older larvae (>5 mm BL) and juvenile stages (>10 mm BL) which account respectively for 12.1% and 78.7% of fish collected in samples (Figure 3). These older larvae and juveniles co-occur with *Sargassum* 78% of the time and primarily when *Sargassum* exceeds 1 liter / 10 min tow. In contrast larvae at 5 mm BL or less only co-occur with *Sargassum* 22% of the time and when little (< 1 liter/ 10 min tow) or no *Sargassum* is observed in the sample. Although, catches of gray triggerfish greater than 5 mm BL are associated with *Sargassum* catch, a clear relationship with increasing catch of gray triggerfish and increasing catches of *Sargassum* was not apparent in our data (Figure 7). However, the ability to elucidate the relationship between gray triggerfish and *Sargassum* CPUE may be limited by the methods used to quantify *Sargassum* in neuston net tows. Currently, the protocols only record liters of *Sargassum* taken in the net, but information on the type of *Sargassum* aggregation, relative density at the surface, at depth and patchiness along or near the neuston tow may be needed to determine a relationship and account for the extreme observations we see in our data. The use of satellite imagery products is being examined to provide a more detailed measurement of Sargassum abundance. This data will be used in future analyses to examine the intricate link between Sargassum abundance and variability of gray triggerfish recruitment in the northern Gulf of America.

Gray triggerfish indices of CPUE derived from SEAMAP Fall Plankton Surveys have been used as an estimate of adult spawning biomass in previous assessments. The juvenile stages which drive annual PPOS and CPUE as estimated from SEAMAP neuston net samples are much further removed from the larval stages (< 10 mm BL) typically used to reflect trends in adult spawning stock. Our examination of gray triggerfish larvae and juveniles associated with *Sargassum* indicates that the current indices primarily represent an index of recruitment to *Sargassum* habitat and not an index of spawning stock biomass. Larval gray triggerfish at or below 5 mm BL from neuston tows could potentially index spawning stock biomass, but larvae in this size range are rare and only occur in 2% of samples over the time series.

Given that the larval and juvenile gray triggerfish PPOS and CPUE indices do not reflect trends in spawning stock biomass, our recommendation is to not include the Gulf of America SEAMAP Fall Plankton Survey index in the assessment model. Based on this recommendation, even though west and east Gulf of America indices were generated for the workshop, they are not presented here.

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Table 1. Factors considered for inclusion into the binomial and negative binomial models. Asterisk (*) indicates factor is only included entire Gulf of America models.

Factors	Levels	Description
Year		
Gulf of America	28	1986 - 1991, 1993 - 1997, 1999- 2003, 2006- 2007, 2009 - 2014, 2016, 2018-2019 and 2022
West	31	1986, 1988 - 1997, 1999 - 2004, 2006 - 2007, 2009 - 2014, 2016 - 2019, 2021 - 2022
East	28	1986 - 1992, 1993 - 1997, 1999 - 2003, 2006 - 2007, 2009 - 2014, 2016, 2018 - 2019 and 2022
Region*	2	West = Western Gulf of America (>89.25 Degrees W Longitude) East = Eastern Gulf of America (< 89.25 Degrees W Longitude)
Time of Day (TOD)	3	D = Day (45 minutes after sunrise to 45 minutes prior to sunset) N = Night (45 minutes after sunset to 45 minutes prior to sunrise) C = Crepuscular (±45 minutes of sunrise and ±45 minutes of sunset)
Depth		Water Depth

Table 2. Nominal catch per unit effort (CPUE) and proportion positive of larval and juvenile gray triggerfish in neuston net samples Gulfwide (Gulf of America) and from the western Gulf of America and the eastern Gulf of America.

Region	N	CPUA	SE CPUA	Proportion Positive	SE Proportion Positive
West	1472	0.4692	0.1068	0.1535	0.0094
East	1686	0.2427	0.0504	0.0824	0.0067
GOM	3158	0.3483	0.0566	0.1156	0.0057

Table 3. Nominal catch per unit effort (CPUE) and proportion positive of larval and juvenile gray triggerfish in neuston net samples by time of day.

Time of Day	N	CPUA	SE CPUA	Proportion Positive	SE Proportion Positive
Day	1488	0.2157	0.0452	0.0927	0.0075
Night	1366	0.4889	0.1200	0.1340	0.0092
Crepuscular	304	0.3654	0.0779	0.1447	0.0202

Table 4. SEAMAP Fall Plankton Survey index of Gulf of America larval and juvenile gray triggerfish relative abundance based on the proportion of positive occurrence binomial model. The nominal proportion positive (PPOS), number of samples (N), the standardize proportion positive (Index), the index scaled to a mean of one (ScaledIndex) for the time series, the coefficient of variation on the mean (CV), and lower (LCL) and upper (UCL) confidence of the scaled index are listed.

Year	*PPOS*	*N*	*Index*	*ScaledIndex*	*CV*	*LCL*	*UCL*
1986	0.12844	109	0.13141	1.10868	0.25535	0.66103	1.78970
1987	0.05172	116	0.05243	0.44230	0.39797	0.20001	0.94444
1988	0.07767	103	0.07486	0.63157	0.34277	0.31772	1.20928
1989	0.05825	103	0.05718	0.48244	0.39971	0.21711	1.03133
1990	0.08850	113	0.08944	0.75456	0.30561	0.40835	1.34510
1991	0.17699	113	0.18754	1.58225	0.20461	1.04180	2.31527
1992							
1993	0.18095	105	0.18333	1.54670	0.21094	1.00534	2.28976
1994	0.14876	121	0.15683	1.32311	0.22016	0.84613	1.99817
1995	0.16949	118	0.18228	1.53780	0.20697	1.00810	2.26110
1996	0.17241	116	0.18323	1.54586	0.20564	1.01612	2.26739
1997	0.10169	118	0.10831	0.91377	0.27636	0.52346	1.53852
1998							
1999	0.05983	117	0.06115	0.51593	0.37395	0.24438	1.05053
2000	0.25714	105	0.26425	2.22936	0.17199	1.56139	3.05608
2001	0.07759	116	0.08258	0.69668	0.32453	0.36318	1.28756
2002	0.13978	93	0.13906	1.17317	0.26366	0.68666	1.91904
2003	0.12821	117	0.12879	1.08656	0.24793	0.65815	1.73175
2004							
2005							
2006	0.22018	109	0.23301	1.96586	0.18323	1.34810	2.75662
2007	0.14754	122	0.15158	1.27885	0.22400	0.81180	1.94602
2008							
2009	0.09402	117	0.09189	0.77522	0.29439	0.42911	1.35333
2010	0.07627	118	0.07731	0.65225	0.32590	0.33944	1.21026
2011	0.08036	112	0.07791	0.65731	0.32817	0.34045	1.22449
2012	0.05000	120	0.04939	0.41671	0.40287	0.18674	0.89904
2013	0.15126	119	0.15239	1.28566	0.22424	0.81563	1.95700
2014	0.10714	112	0.10498	0.88570	0.28107	0.50275	1.50500
2015							
2016	0.07500	120	0.07485	0.63148	0.32632	0.32851	1.17344
2017							
2018	0.07826	115	0.07623	0.64309	0.32880	0.33277	1.19994
2019	0.09184	98	0.08742	0.73752	0.32854	0.38096	1.37102
2020							
2021							
2022	0.06195	113	0.05922	0.49962	0.37554	0.23600	1.02104

Table 5. SEAMAP Fall Plankton Survey index of Gulf of America larval and juvenile gray triggerfish index of relative abundance developed using the negative binomial (NB) model. The nominal proportion positive (PPOS), number of samples (N), the catch per unit effort (Index) expresses as number per 10 minute tow, the index scaled to a mean of one (ScaledIndex) for the time series, the coefficient of variation on the mean (CV), and lower (LCL) and upper (UCL) confidence of the scaled index are listed.

Year	*PPOS*	*N*	*Index*	*ScaledIndex*	*CV*	*LCL*	*UCL*
1986	0.12844	109	0.22844	0.77578	0.35606	0.38596	1.5593
1987	0.05172	116	0.25732	0.87387	0.38665	0.40945	1.8651
1988	0.07767	103	0.10376	0.35239	0.43145	0.15123	0.8211
1989	0.05825	103	0.05495	0.18663	0.51076	0.06856	0.5081
1990	0.08850	113	0.11830	0.40176	0.41170	0.17922	0.9006
1991	0.17699	113	0.23802	0.80832	0.35946	0.39948	1.6356
1992							
1993	0.18095	105	0.26430	0.89756	0.36621	0.43775	1.8404
1994	0.14876	121	0.28191	0.95736	0.33831	0.49317	1.8585
1995	0.16949	118	0.33753	1.14627	0.32993	0.60026	2.1889
1996	0.17241	116	0.61827	2.09968	0.32438	1.11157	3.9662
1997	0.10169	118	0.20583	0.69902	0.36180	0.34388	1.4209
1998							
1999	0.05983	117	0.07808	0.26516	0.48176	0.10310	0.6819
2000	0.25714	105	0.69449	2.35853	0.32912	1.23705	4.4967
2001	0.07759	116	0.15471	0.52541	0.40676	0.23667	1.1665
2002	0.13978	93	1.46616	4.97915	0.37433	2.39003	10.3731
2003	0.12821	117	0.20419	0.69343	0.35805	0.34365	1.3992
2004							
2005							
2006	0.22018	109	0.53928	1.83143	0.33297	0.95335	3.5182
2007	0.14754	122	0.52746	1.79128	0.31889	0.95857	3.3474
2008							
2009	0.09402	117	0.18234	0.61923	0.39075	0.28782	1.3323
2010	0.07627	118	0.17510	0.59464	0.40041	0.27120	1.3038
2011	0.08036	112	0.09287	0.31540	0.45354	0.12962	0.7675
2012	0.05000	120	0.07499	0.25467	0.45474	0.10441	0.6212
2013	0.15126	119	0.37400	1.27013	0.34497	0.64580	2.4980
2014	0.10714	112	0.16013	0.54382	0.39499	0.25068	1.1798
2015							
2016	0.07500	120	0.13984	0.47489	0.37286	0.22861	0.9865
2017							
2018	0.07826	115	0.08948	0.30389	0.44989	0.12578	0.7342
2019	0.09184	98	0.14749	0.50089	0.41882	0.22034	1.1386
2020							
2021							
2022	0.06195	113	0.43563	1.47943	0.33589	0.76573	2.8583

Table 6. Summary of factor selection for the Gulf of America indices of gray triggerfish proportion of positive occurrence (PPOS) binomial model (top) and catch per unit effort (CPUE) negative binomial model (bottom) .

Gulf of America Type III Tests of Fixed Effects						
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
YEAR	27	3126	82.73	3.06	<.0001	<.0001
TOD	2	3126	18.61	9.31	<.0001	<.0001
REGION	1	3126	50.31	50.31	<.0001	<.0001
DEPTH	1	3126	58.96	58.96	<.0001	<.0001

Gulf of America Type III Tests of Fixed Effects						
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
YEAR	27	3126	104.81	3.88	<.0001	<.0001
TOD	2	3126	23.53	11.77	<.0001	<.0001
EW	1	3126	50.6	50.6	<.0001	<.0001
DEPTH	1	3126	67	67	<.0001	<.0001

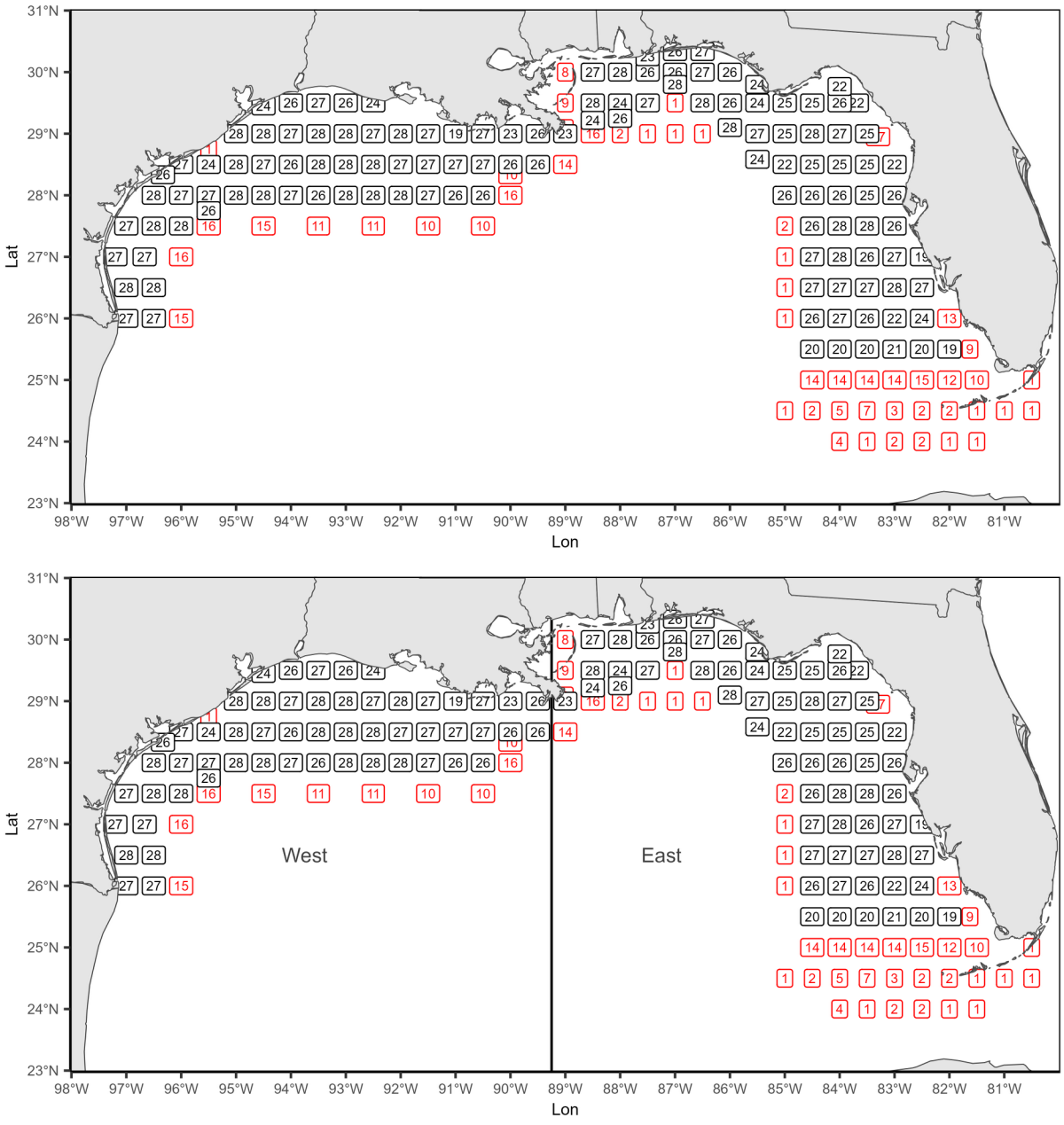


Figure 1. Number of primary neuston net samples taken at each SEAMAP systematic grid location from the annual SEAMAP Fall Plankton Surveys included in the Gulf of America index (top) and west and east regions (bottom). Only locations with primary samples equal to or exceeding 19 were included in the Gulf of America index, locations equal to or exceeding 21 were included in the west index, and locations equal to or exceeding 19 were included in the east index. Black locations indicate included stations and red those excluded.

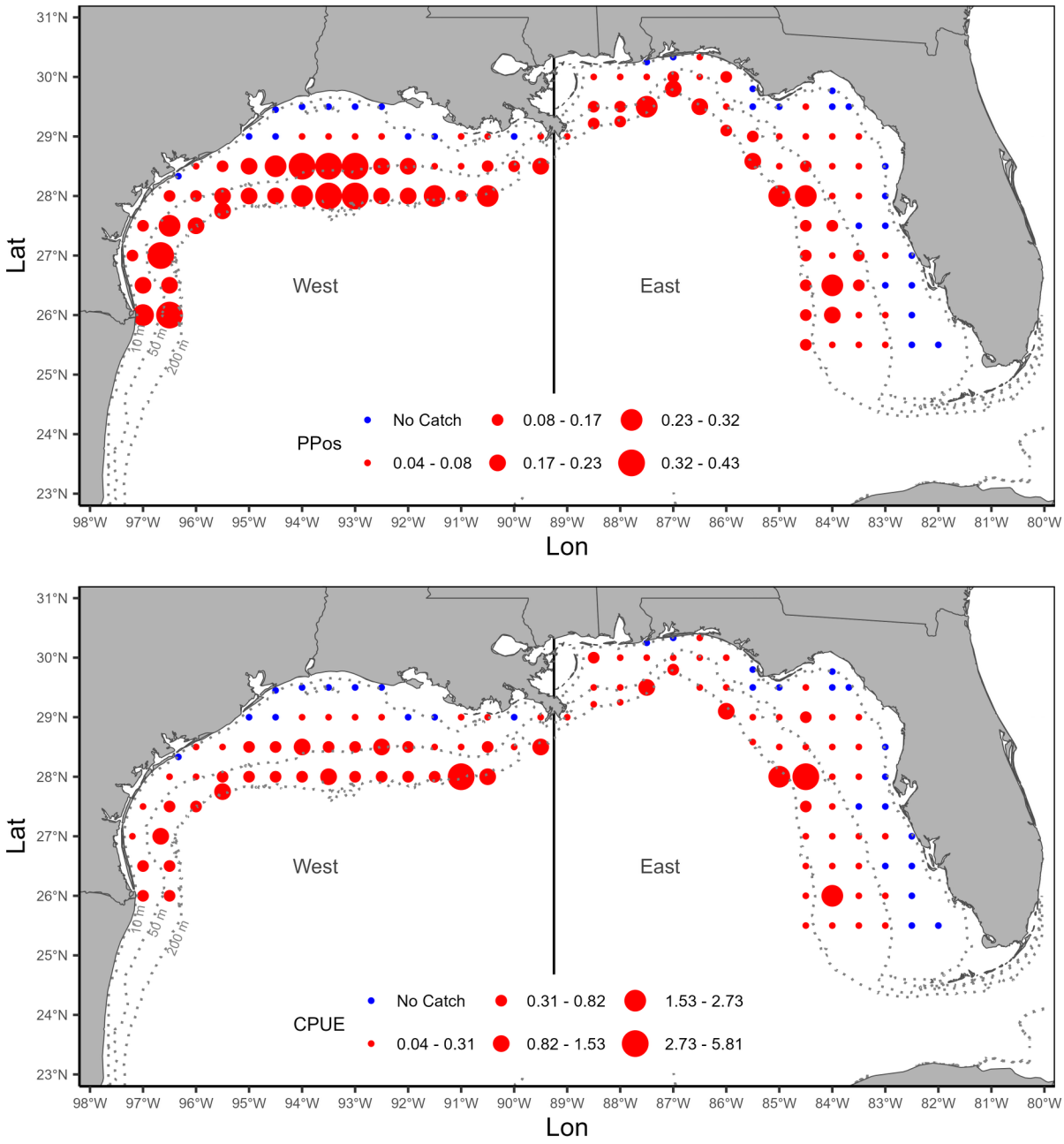


Figure 2. Gray triggerfish proportion positive (PPos, upper) and mean catch per unit effort (CPUE, lower) from Fall Plankton Survey neuston net samples used to develop Gulf of America indices of abundance. CPUE is expressed as number per 10 minute tow.

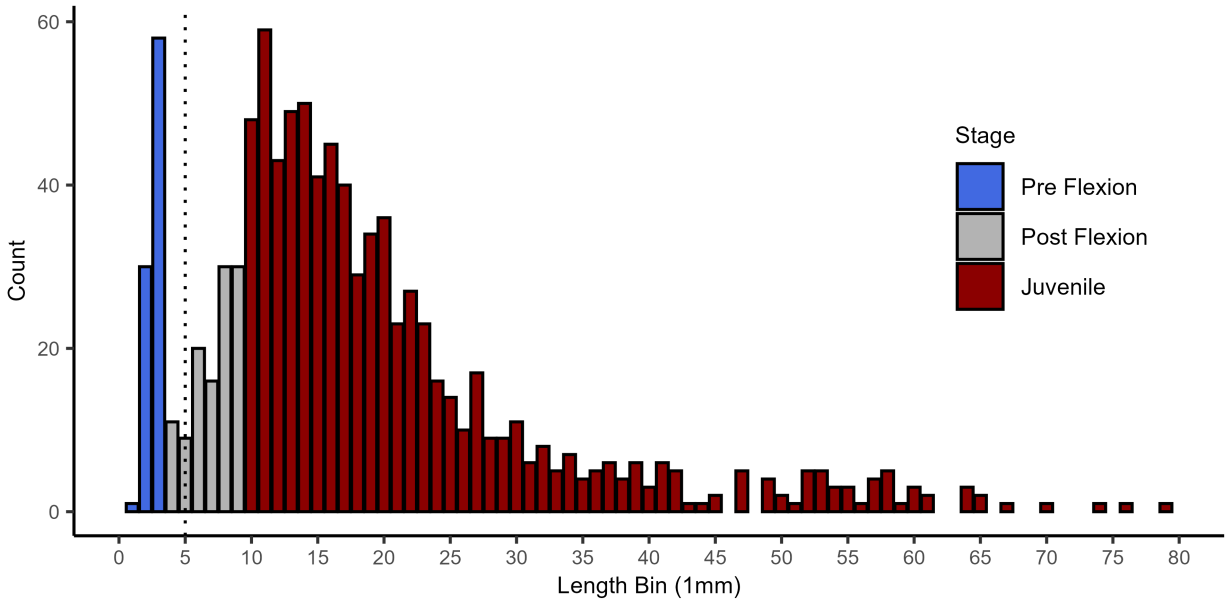


Figure 3. Length frequencies of gray triggerfish from neuston net samples collected during the SEAMAP Fall Plankton surveys. Length data includes all samples use to generate indices of relative abundance for the entire Gulf of America.

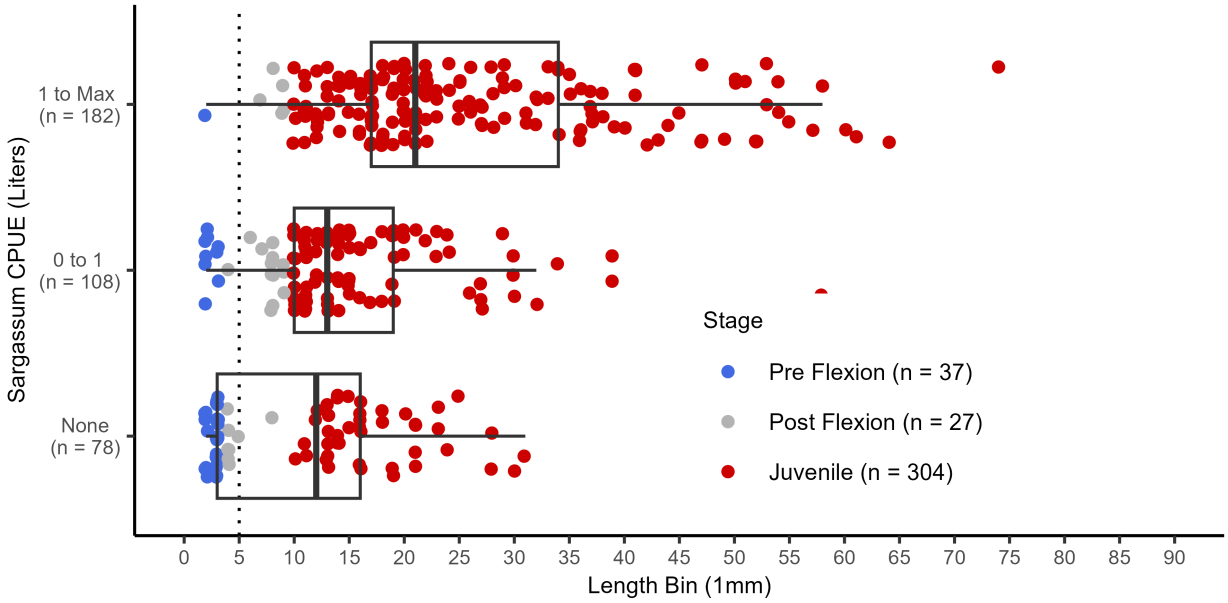
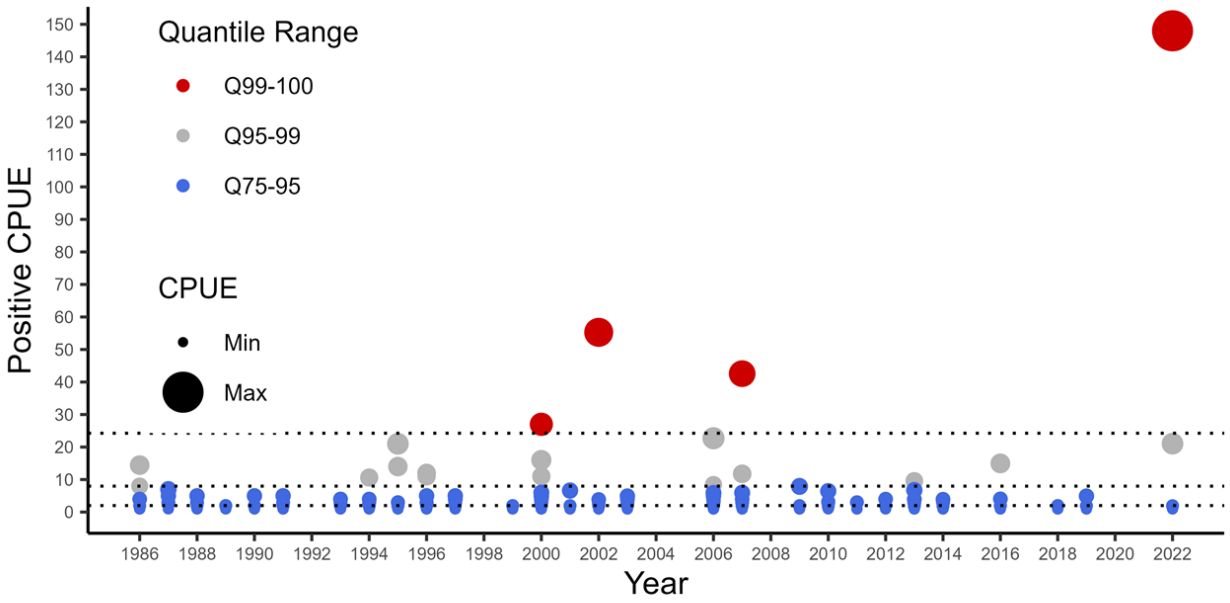


Figure 4. Lengths of gray triggerfish from neuston net samples collected during the SEAMAP Fall Plankton surveys for which sargassum data is available from 2006 to 2022 Gulf of America index samples.



0%	1%	5%	25%	50%	75%	95%	99%	100%
0.85	0.94	0.96	1.00	1.00	2.00	7.98	24.25	148.01

Figure 5. Gray triggerfish positive (non-zero) CPUE (number / 10 min tow) from Gulf of America index samples (n = 365) by year. Dotted refeence lines from bottom to top are the 75th, 95th and 99th quantiles of all postive CPUE values.

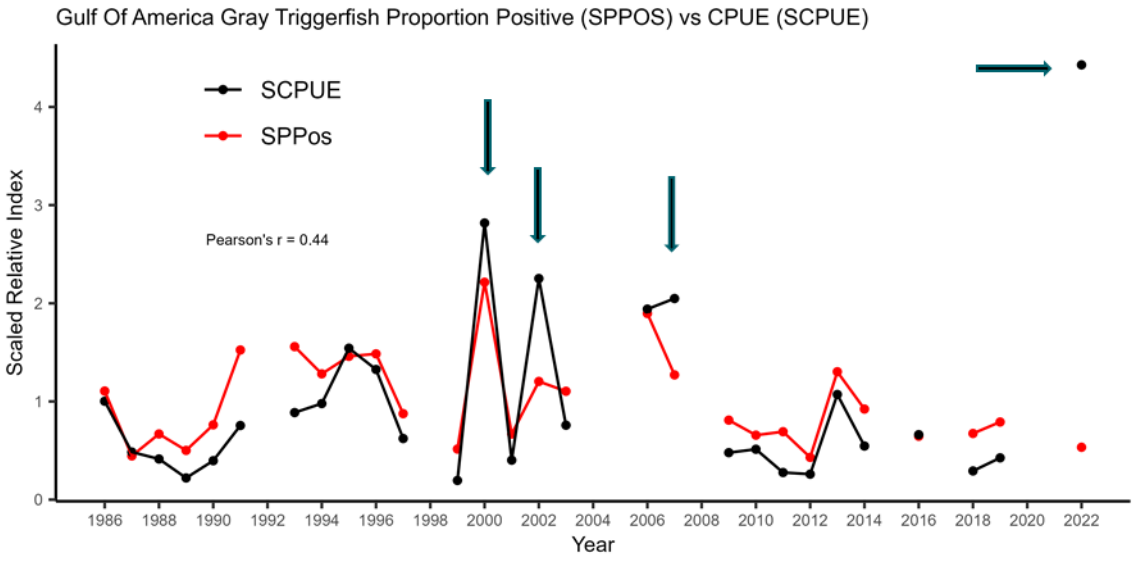


Figure 6. Gray triggerfish nominal scaled proportion positive (SPPos) and catch per unit effort (SCPUE). Annual SPPos and SCPUE Values are scaled to a mean of one. Arrows indicate years with extreme values exceeding the 99th quantile of positive CPUE observations.

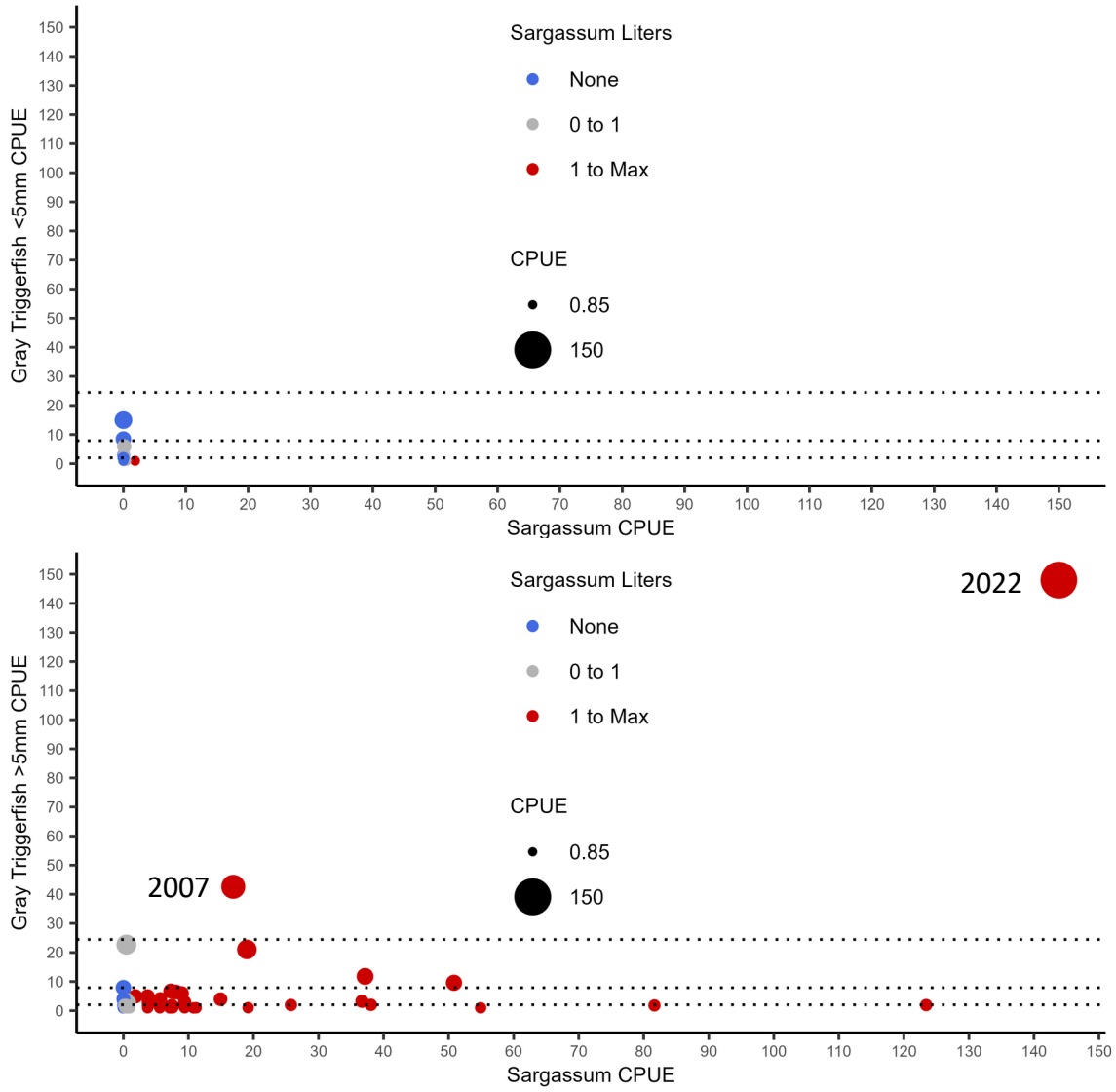


Figure 7. Gray triggerfish positive (non-zero) CPUE (number / 10 min tow) in relation to Sargassum CPUE (liters / 10 min tow) for fish 5 mm in body length or less (top, n = 23) and fish greater than 5 mm body length (bottom, n = 121) from 2006 to 2022 Gulf of America index samples . Dotted refeence lines from bottom to top are the 75th, 95th and 99th quantiles of all postive CPUE values. Dot size is based on gray triggerish CPUE. Colors reflect Sargassum catch categories. Anotated values of 2007 and 2022 identify extreme values identied in all Gulf of America positive CPUE values show in Figure 5.

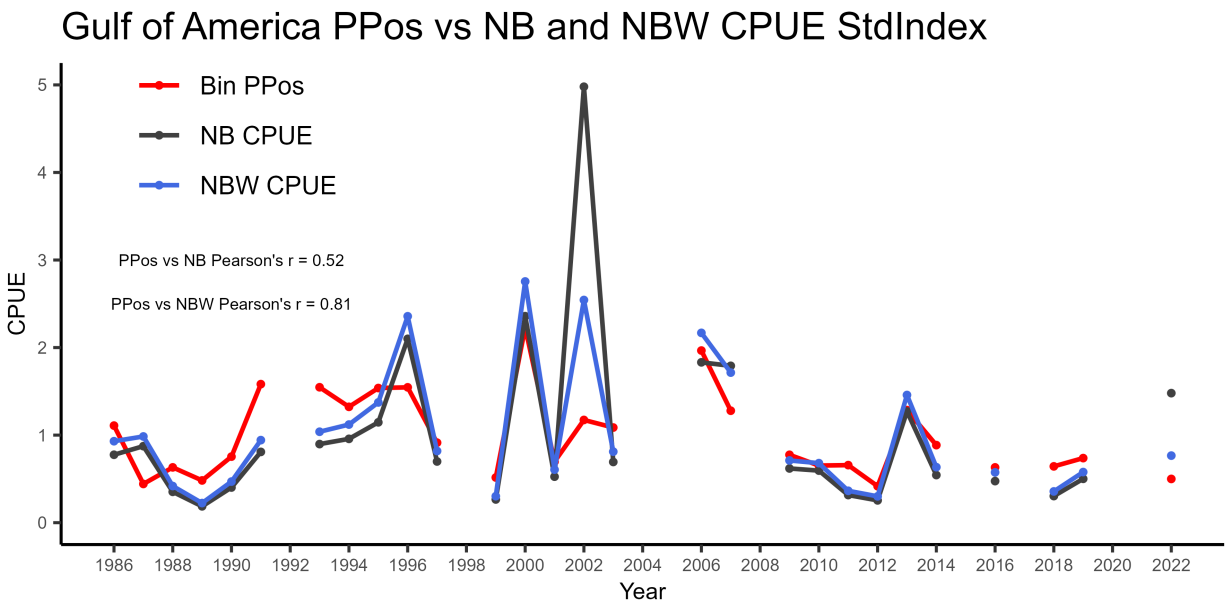


Figure 8. Standardized gray triggerfish indices of proportion of positive occurrence (Bin PPOS) negative binomial catch per unit effort (NB CPUE) and negative binomial catch per unit effort (NBW CPUE) when accounting for extreme observations in Gulf of America index samples.

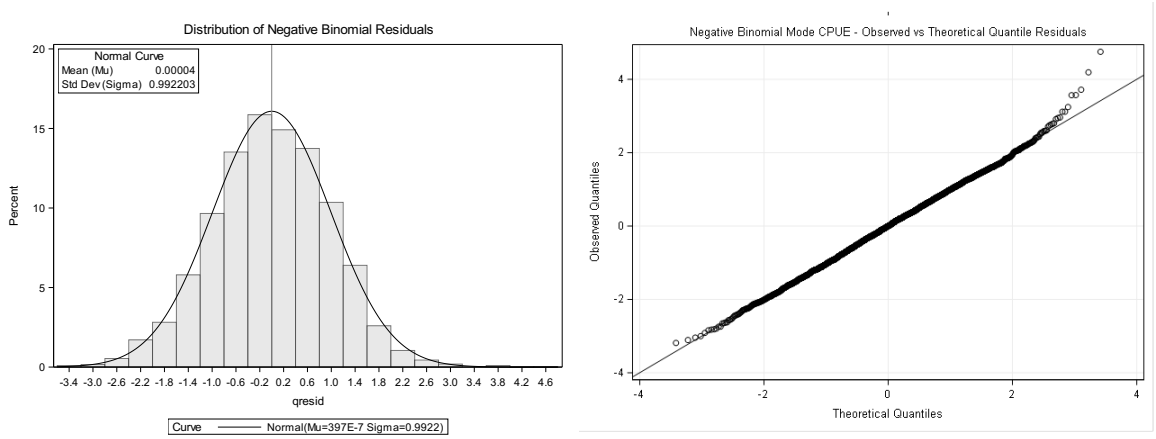
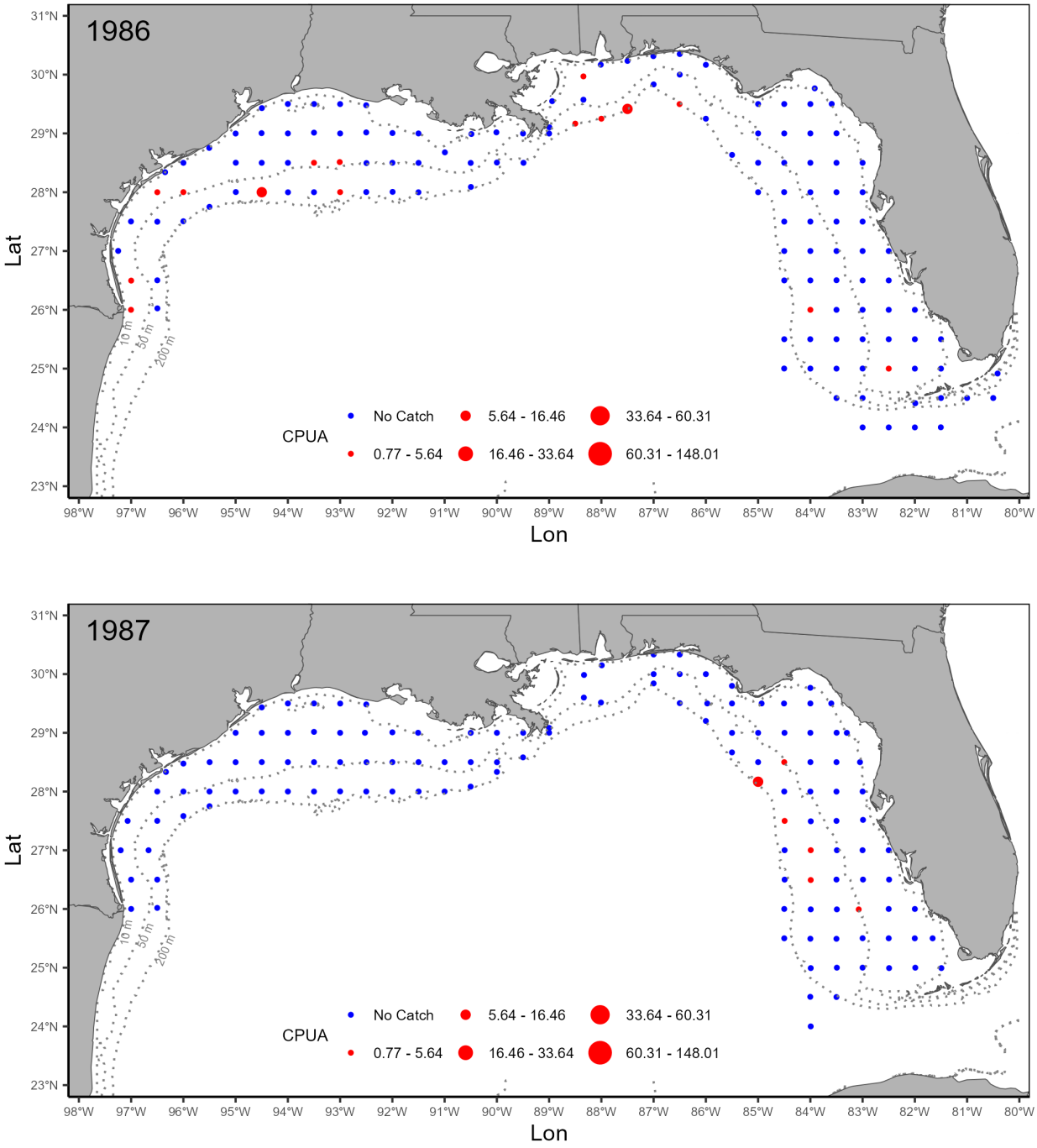
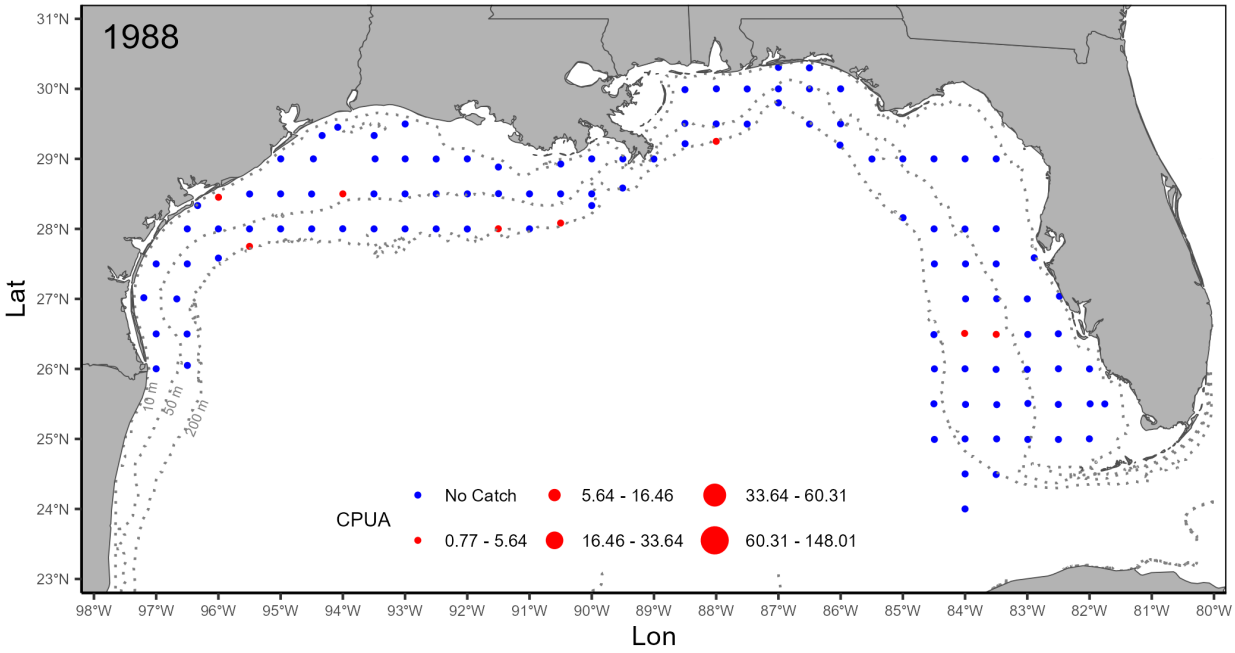


Figure 9. Distributions (left) and QQ plots (right) of residuals from the negative binomial models of larval and juvenile gray triggerfish CPUE from SEAMAP Fall Plankton Surveys for the entire (top), west (middle) and east (bottom) Gulf of America.

Appendix Figure 1. Annual survey effort and catch per unit effort (CPUE) of gray triggerfish larvae and juveniles from the SEAMAP Fall Plankton Survey conducted from 1986-2016. CPUE is expressed as fish per 10 minute tow.

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Lat
Lon
CPUA
No Catch
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5.64 - 16.46
16.46 - 33.64
33.64 - 60.31
60.31 - 148.01
10 m
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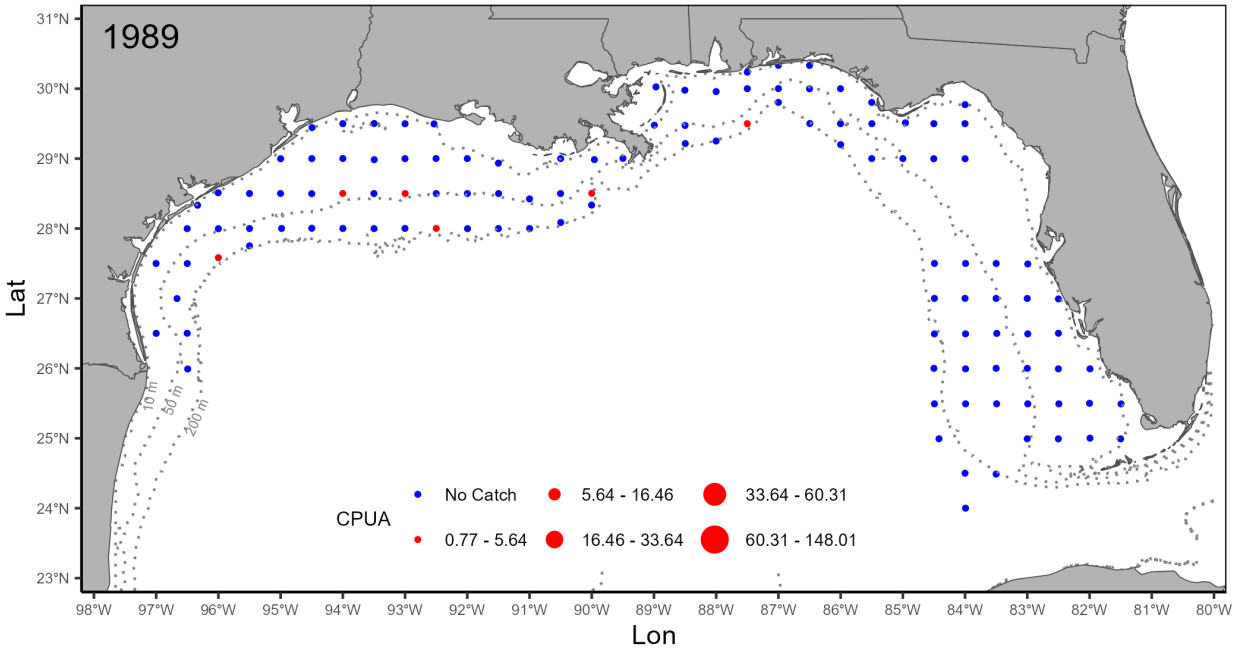
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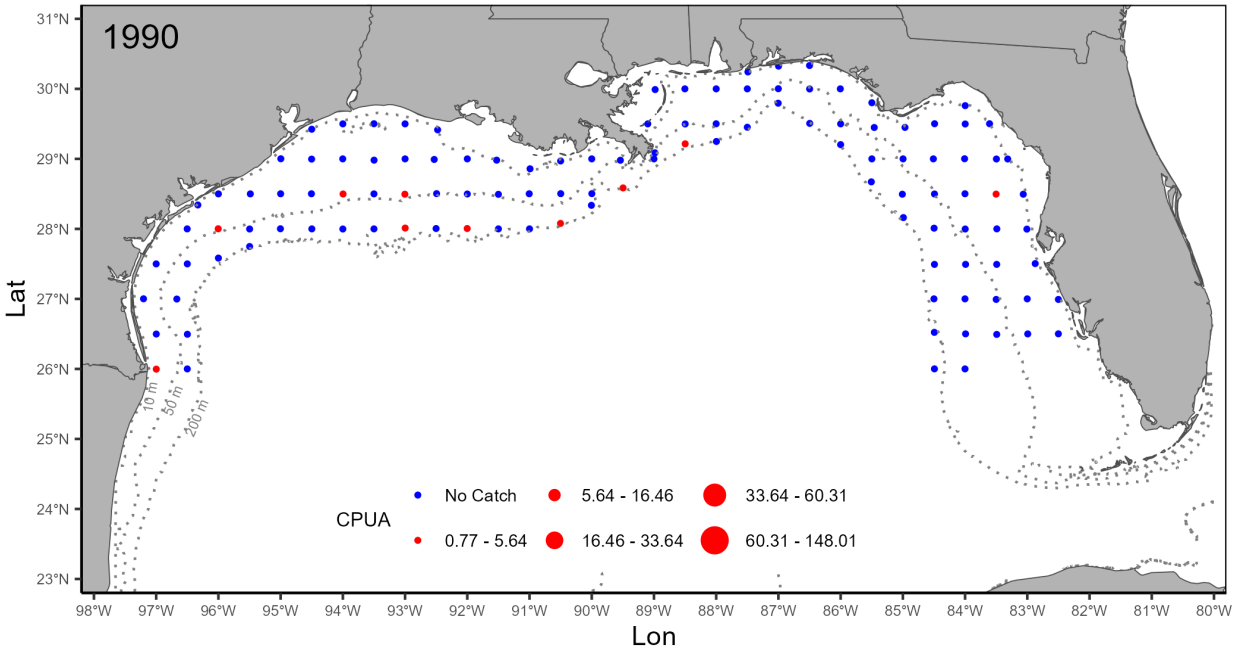
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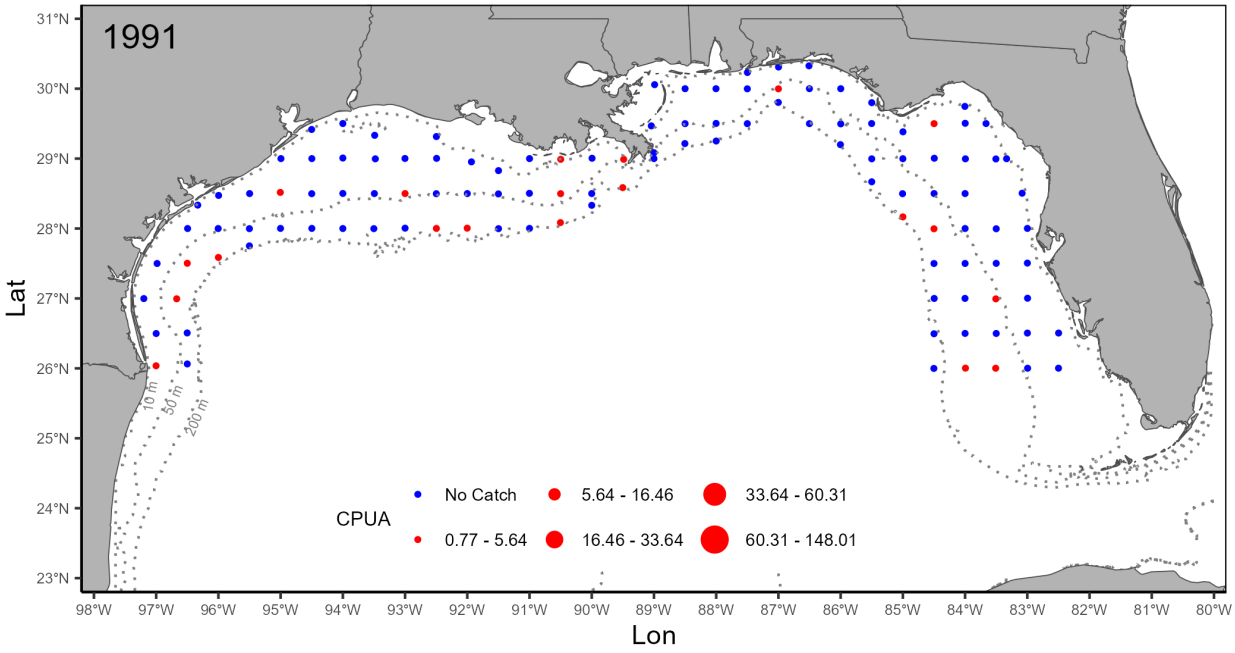
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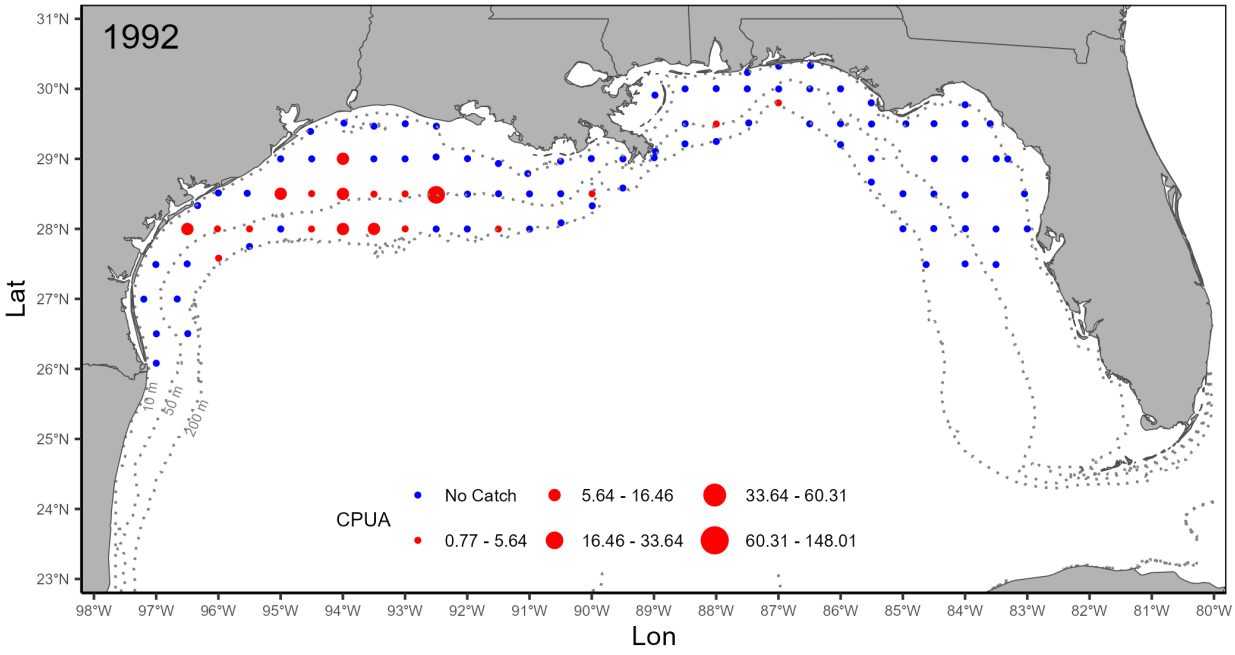
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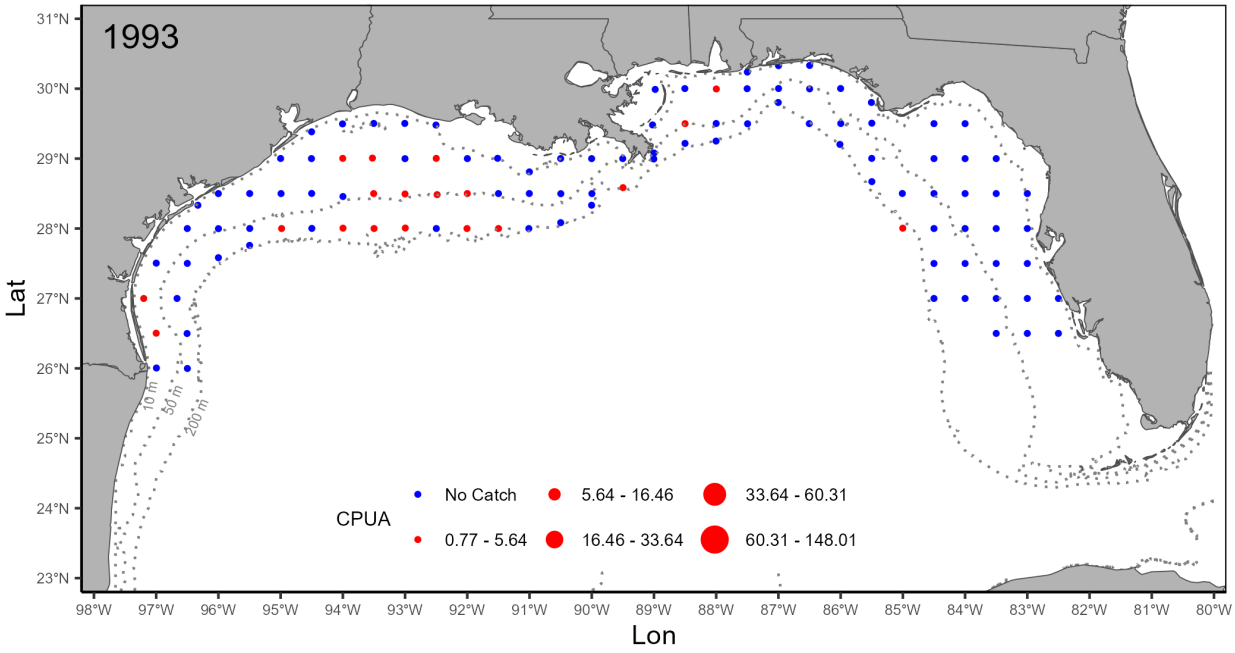
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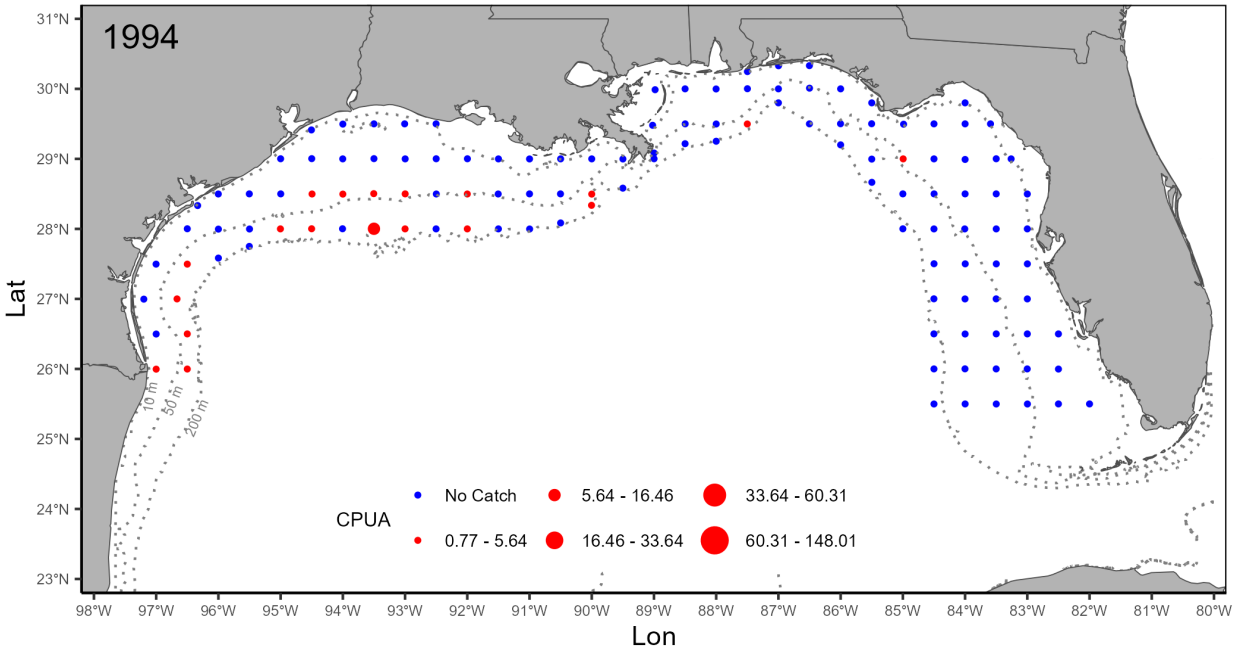
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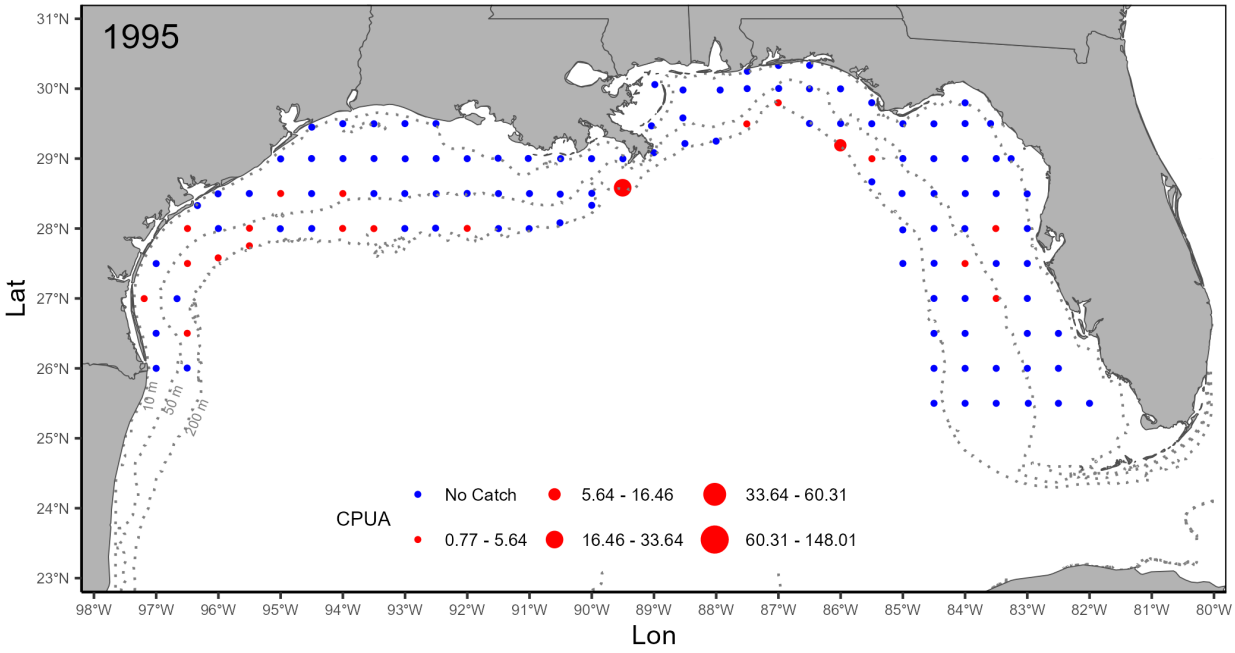
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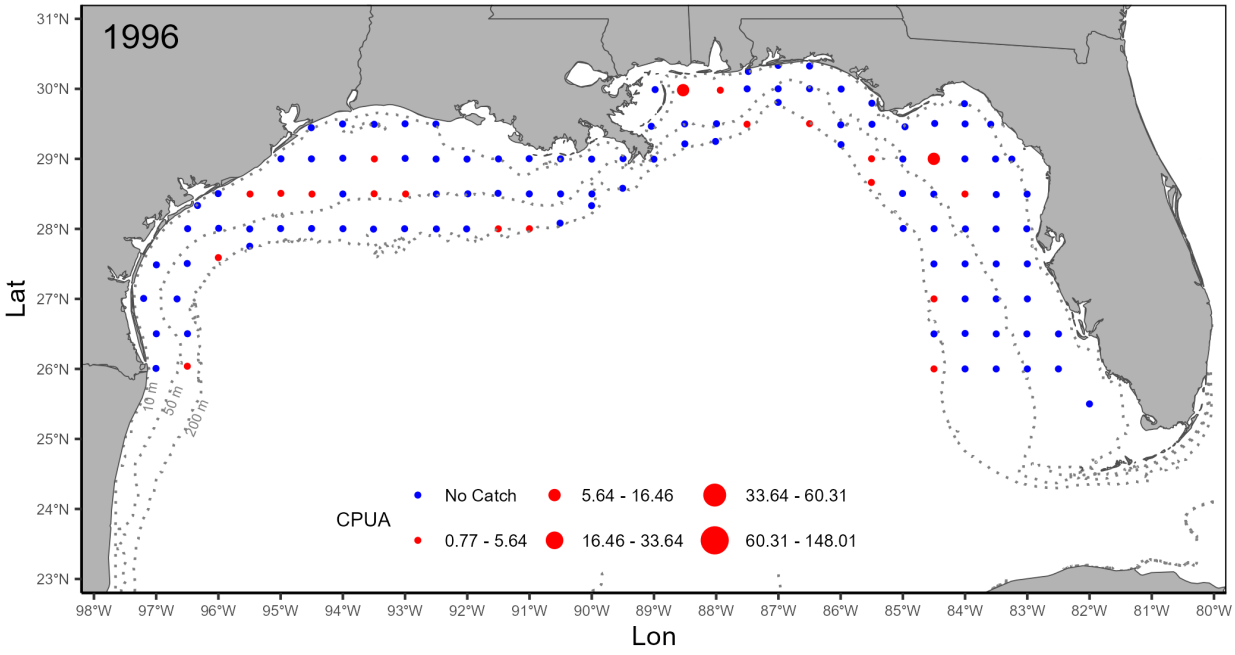
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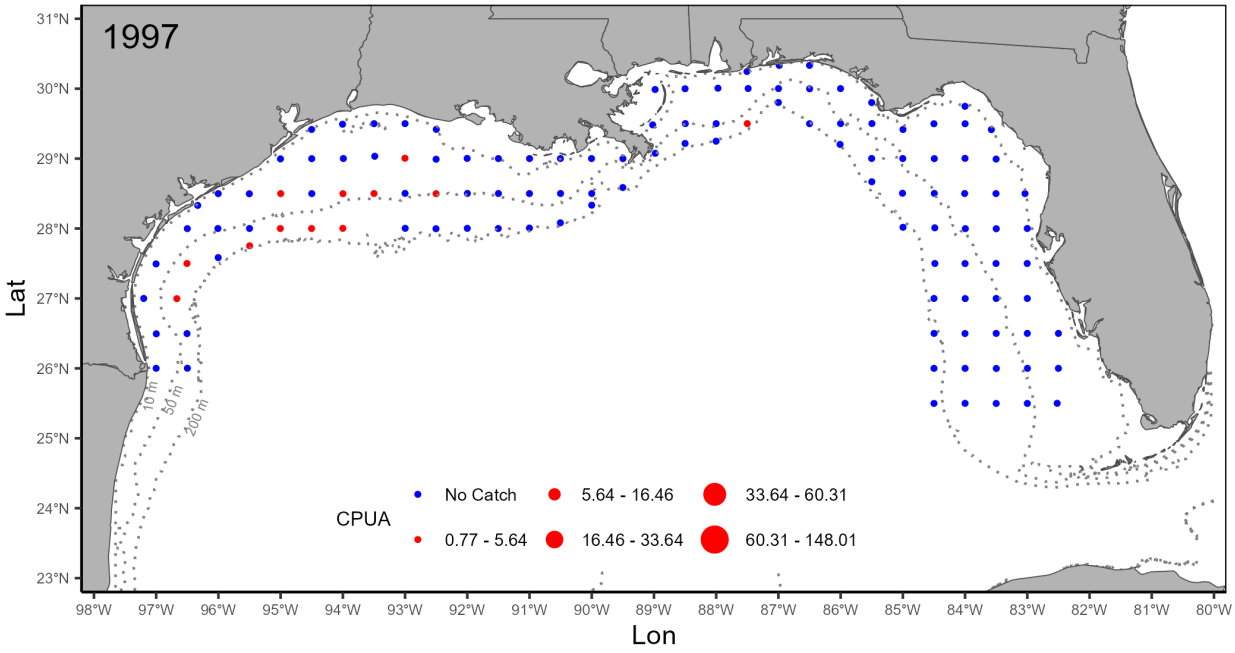
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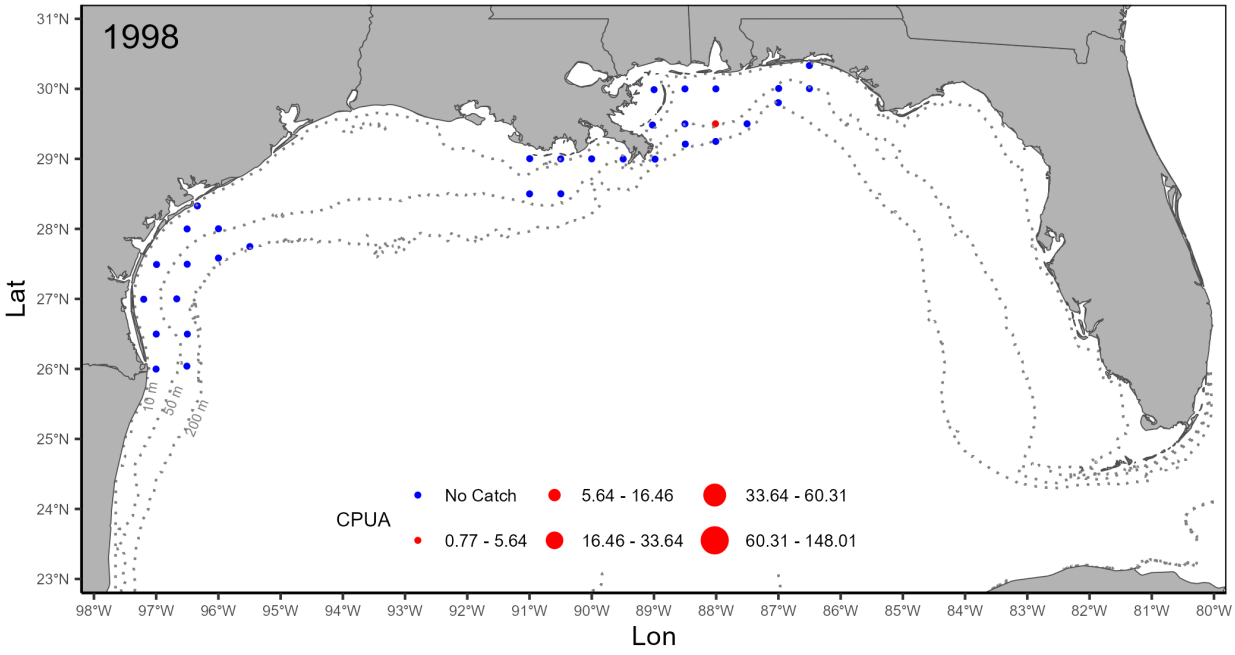
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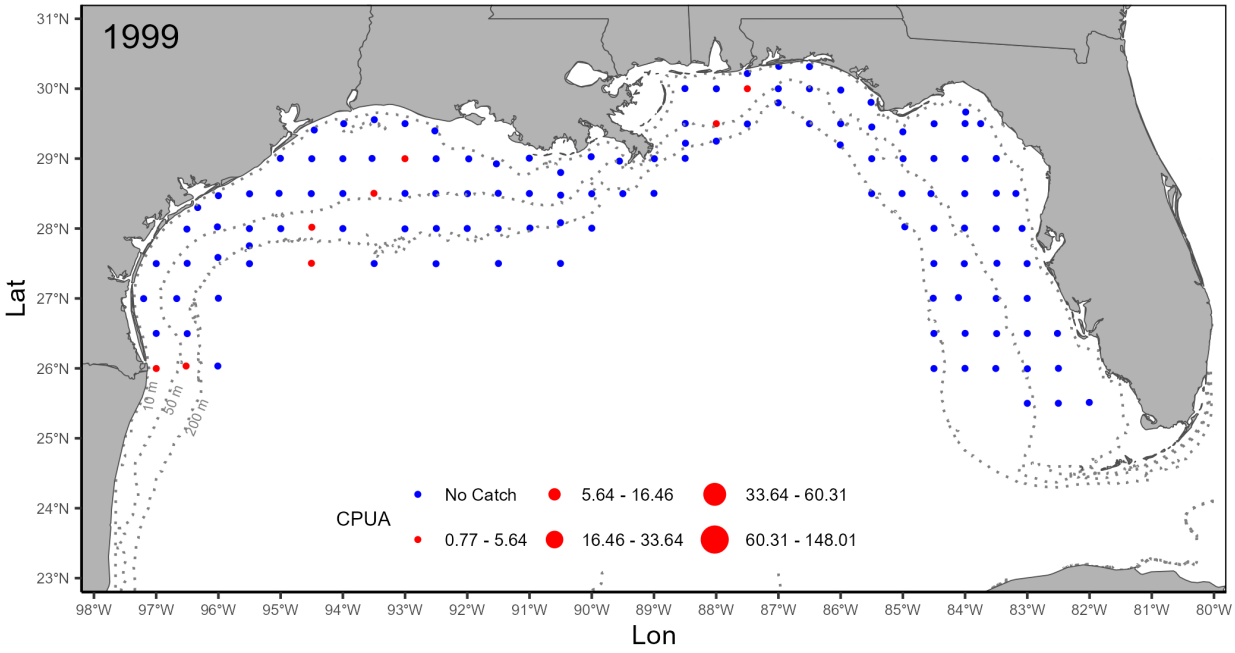
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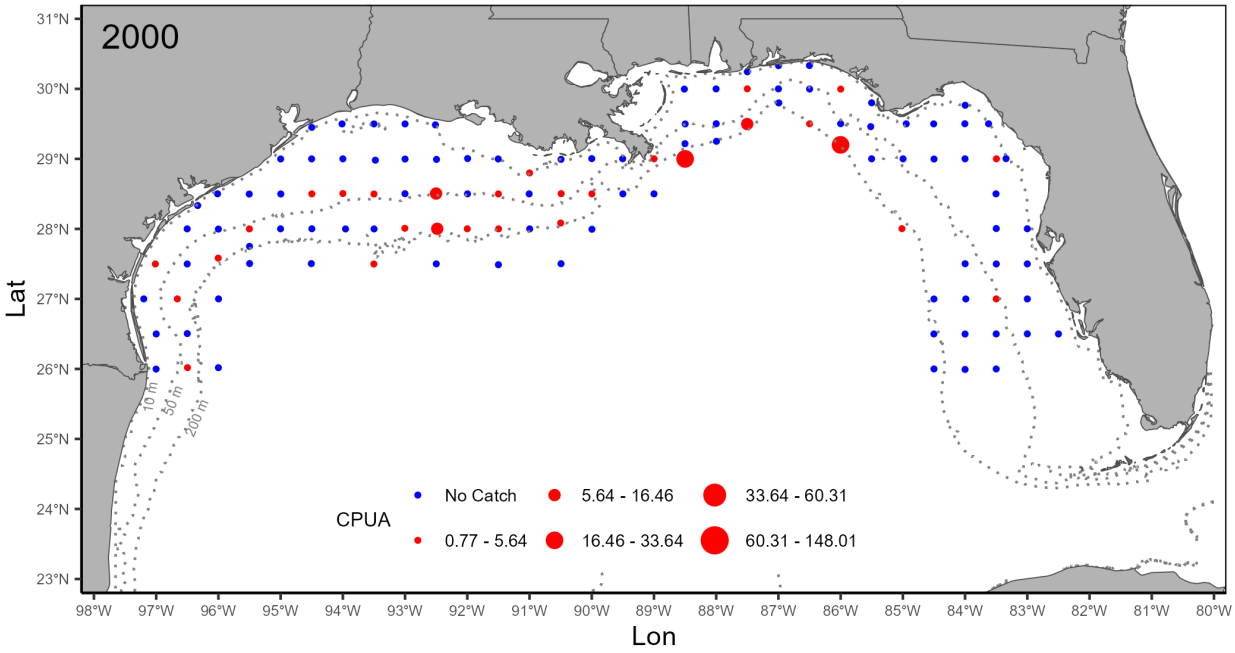
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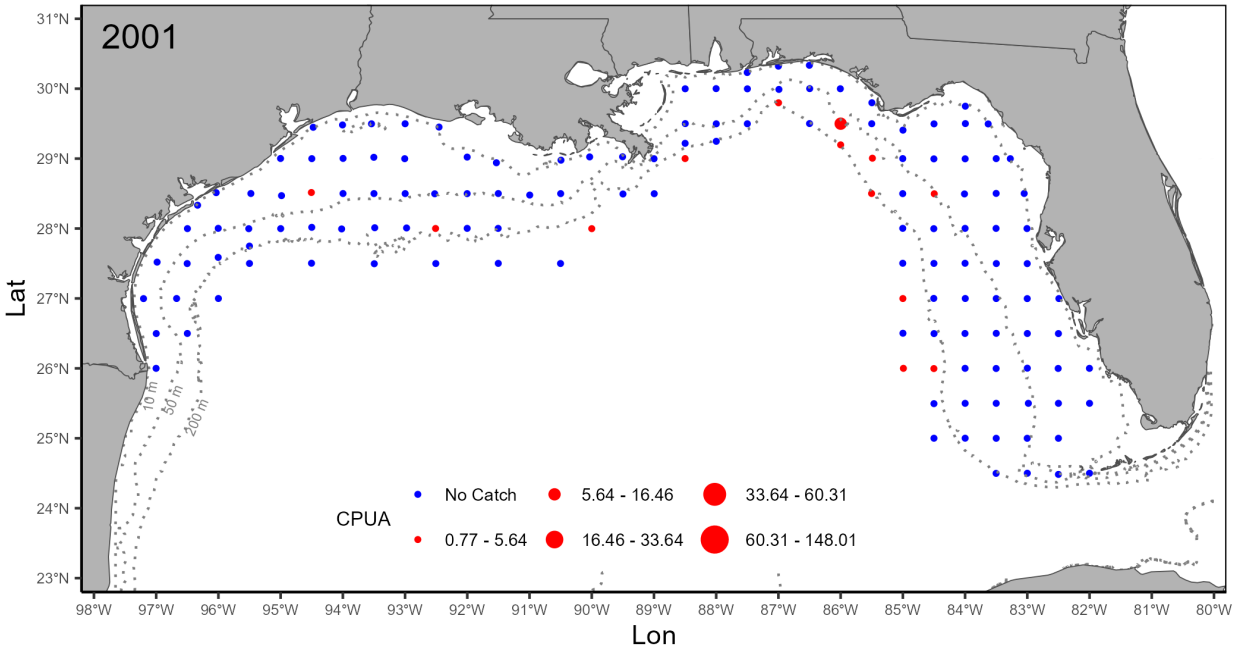
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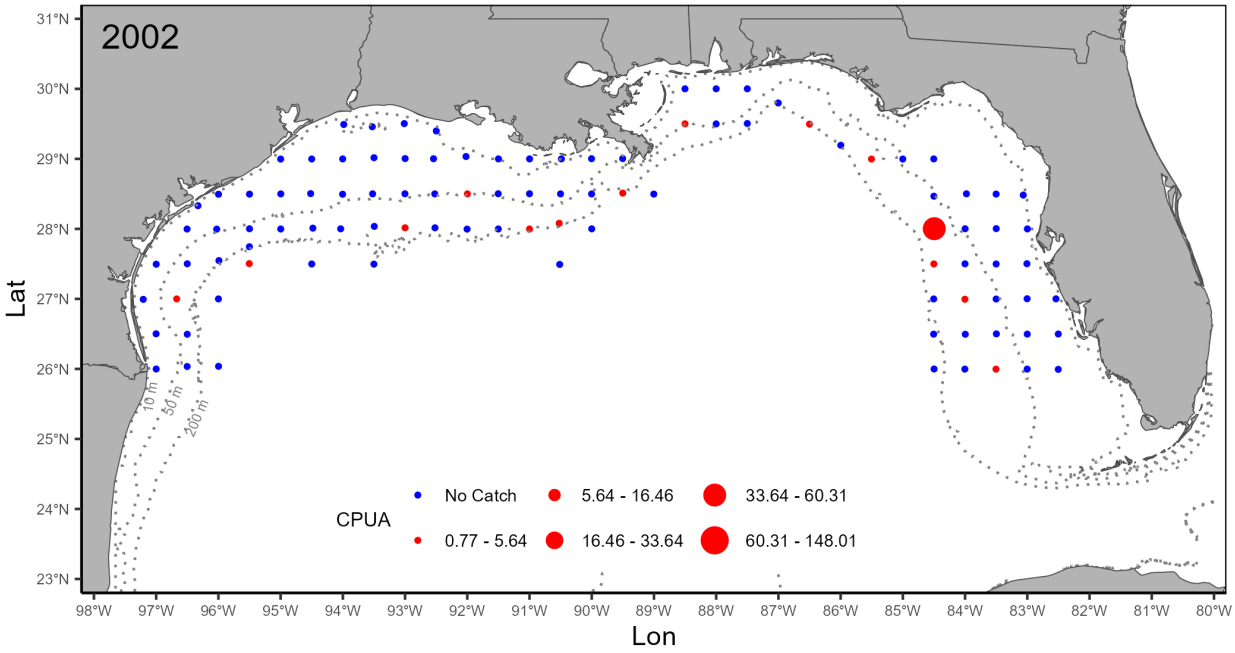
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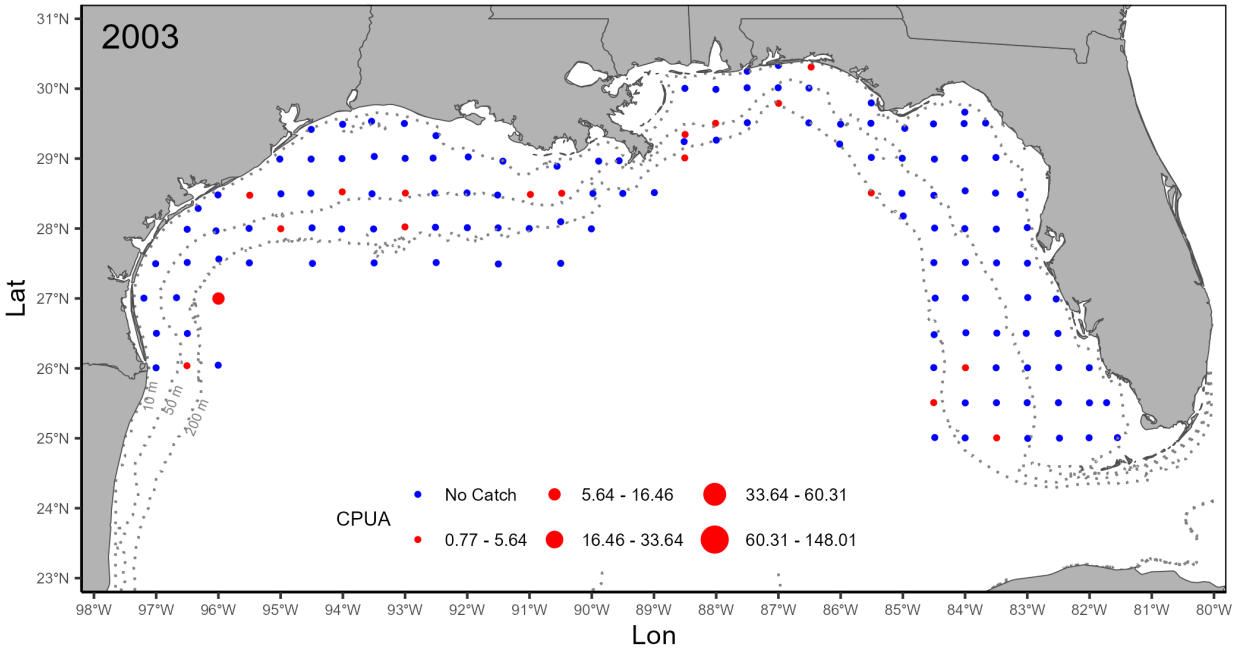
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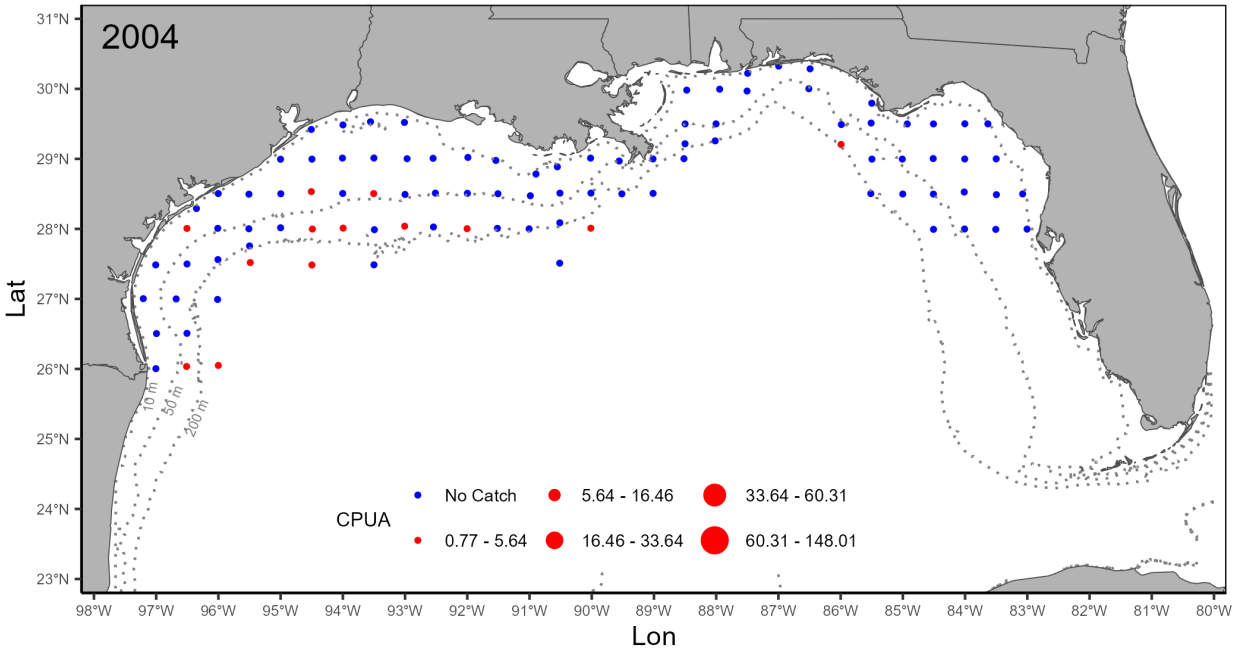
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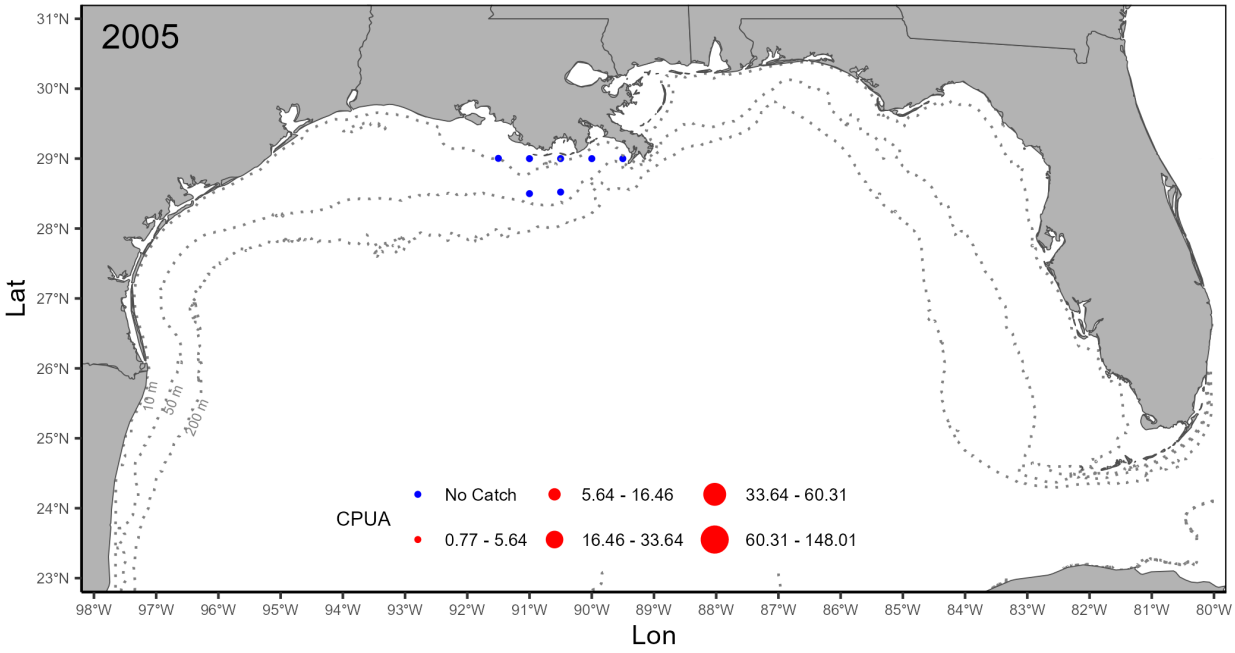
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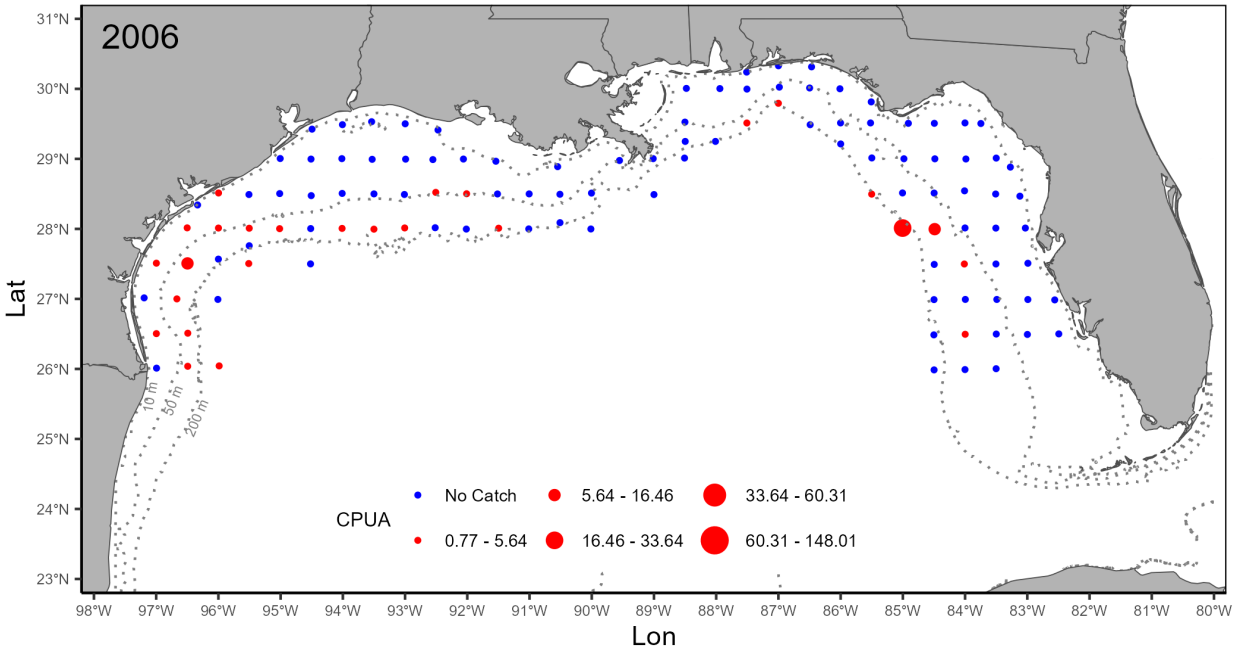
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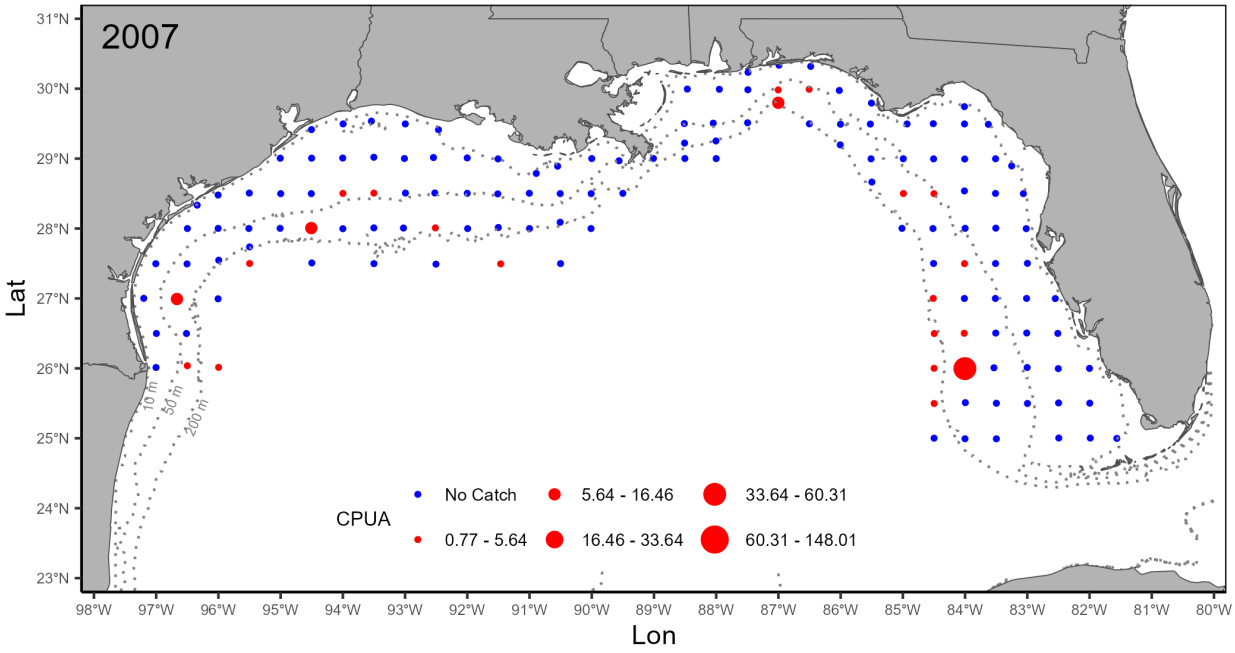
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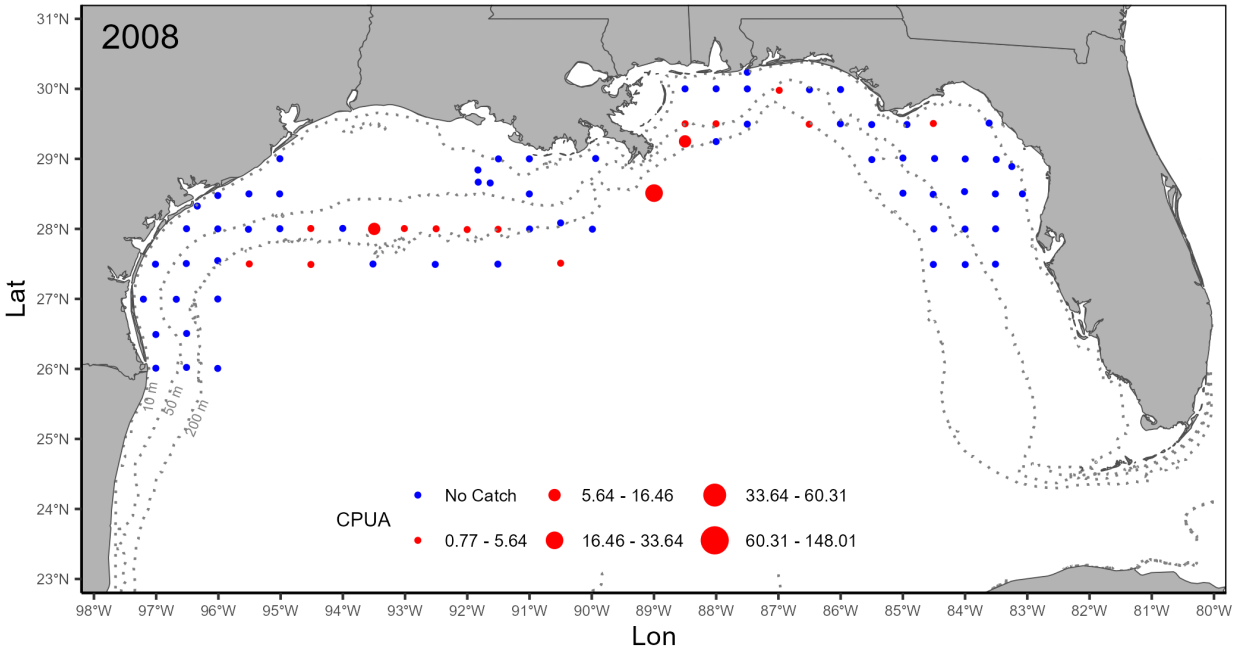
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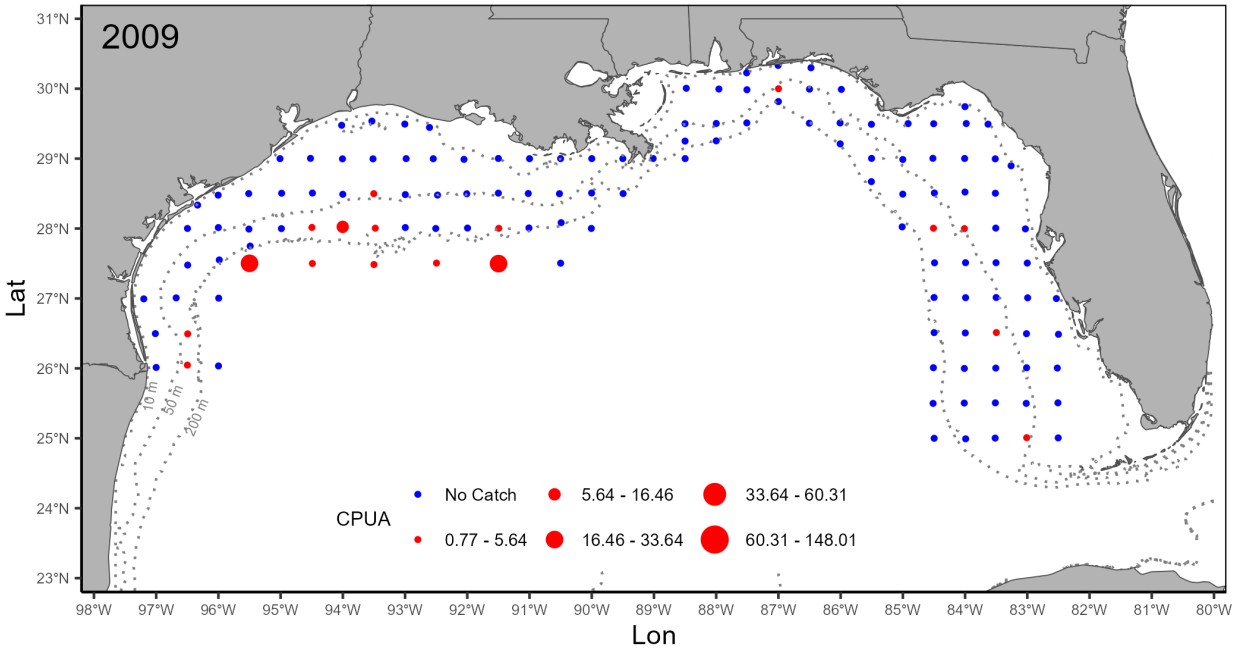
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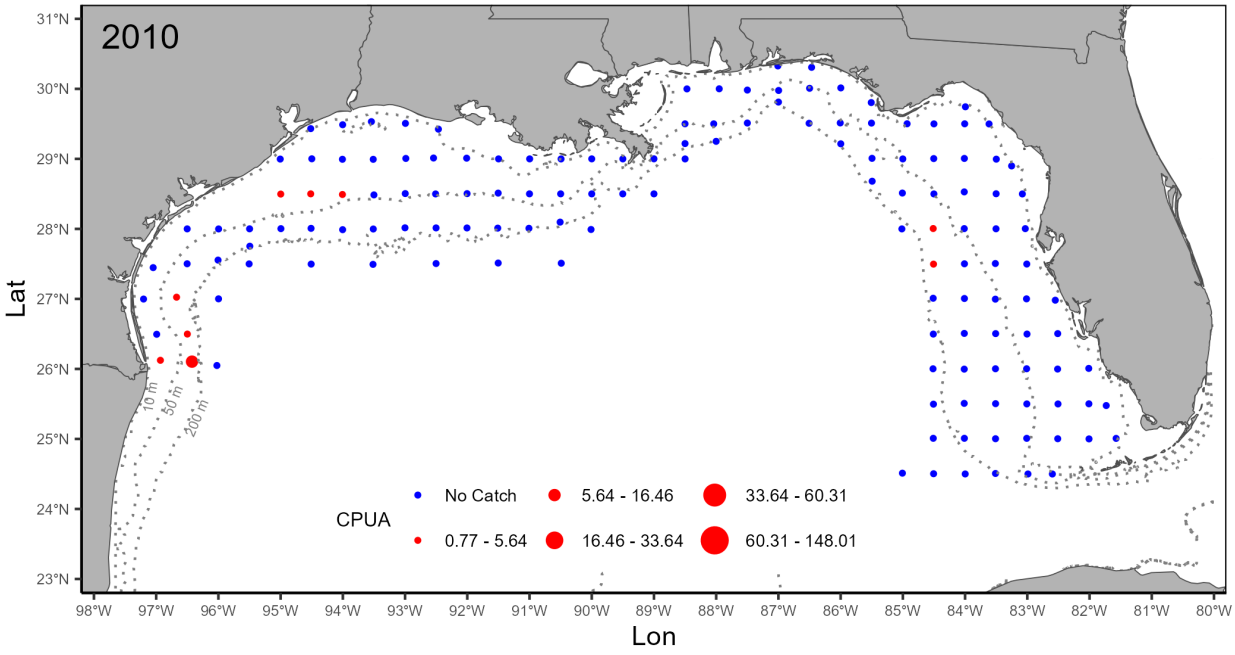
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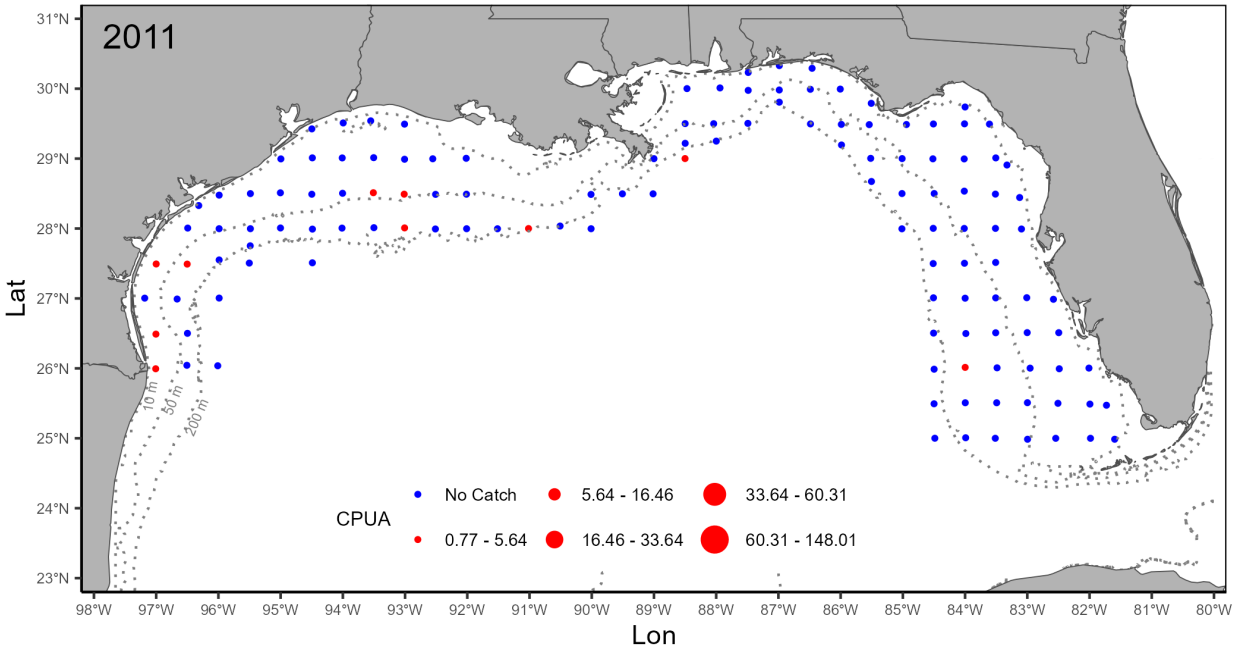
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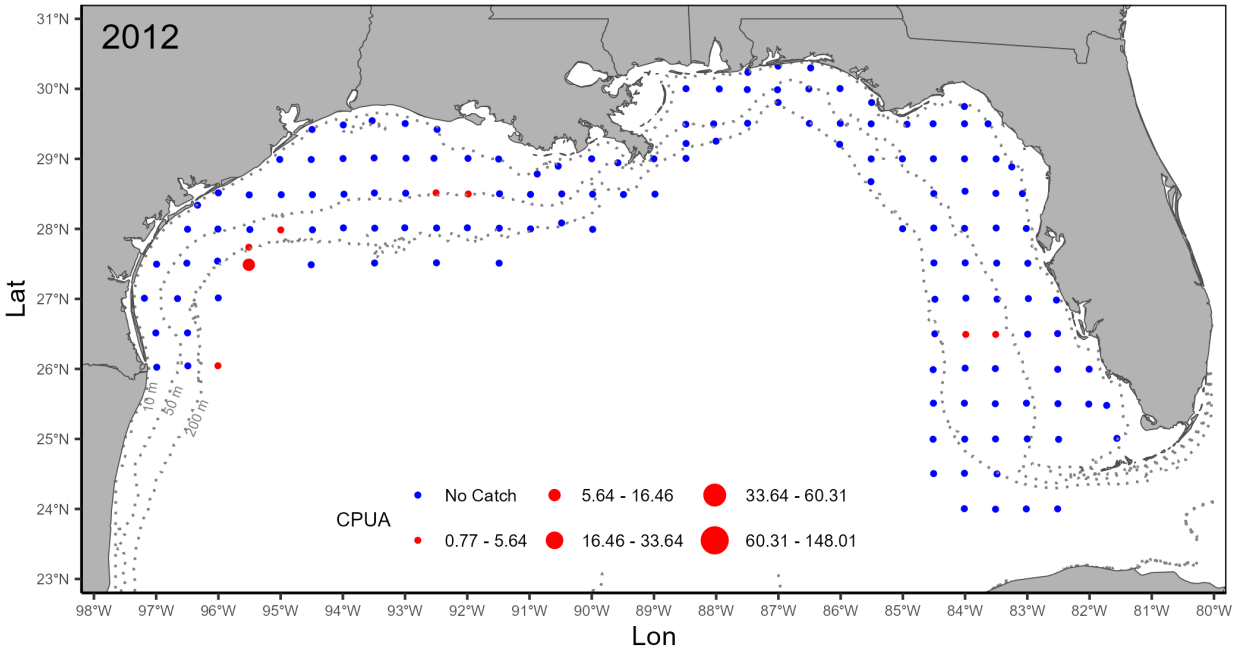
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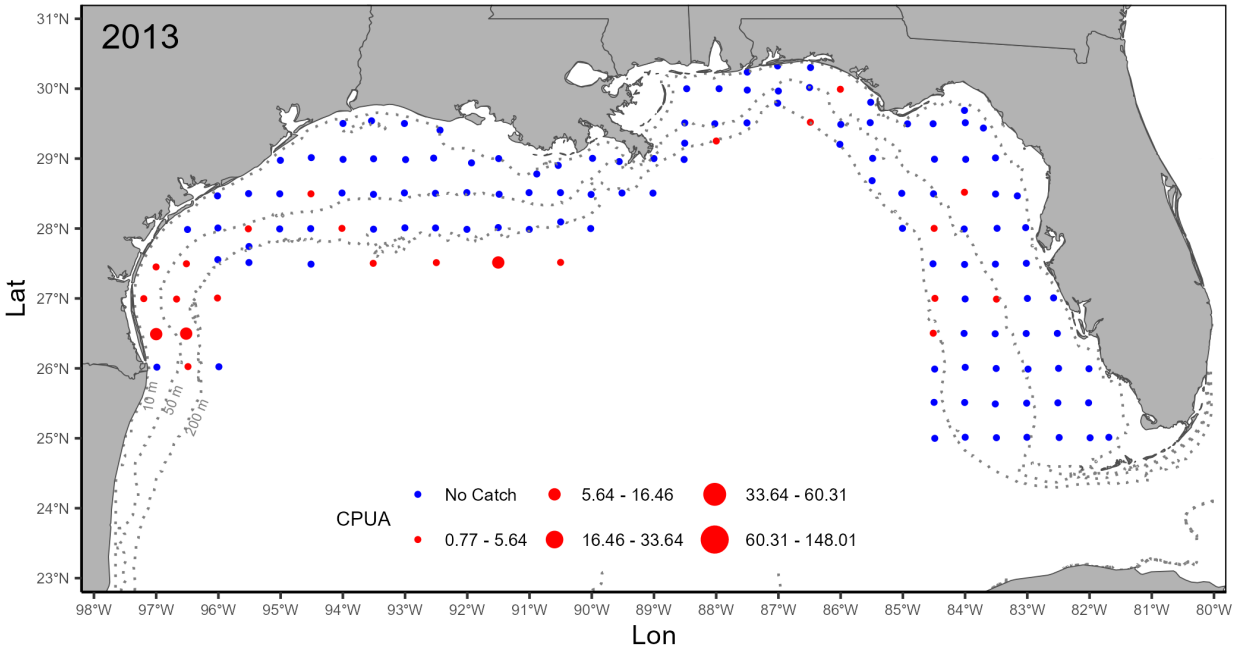
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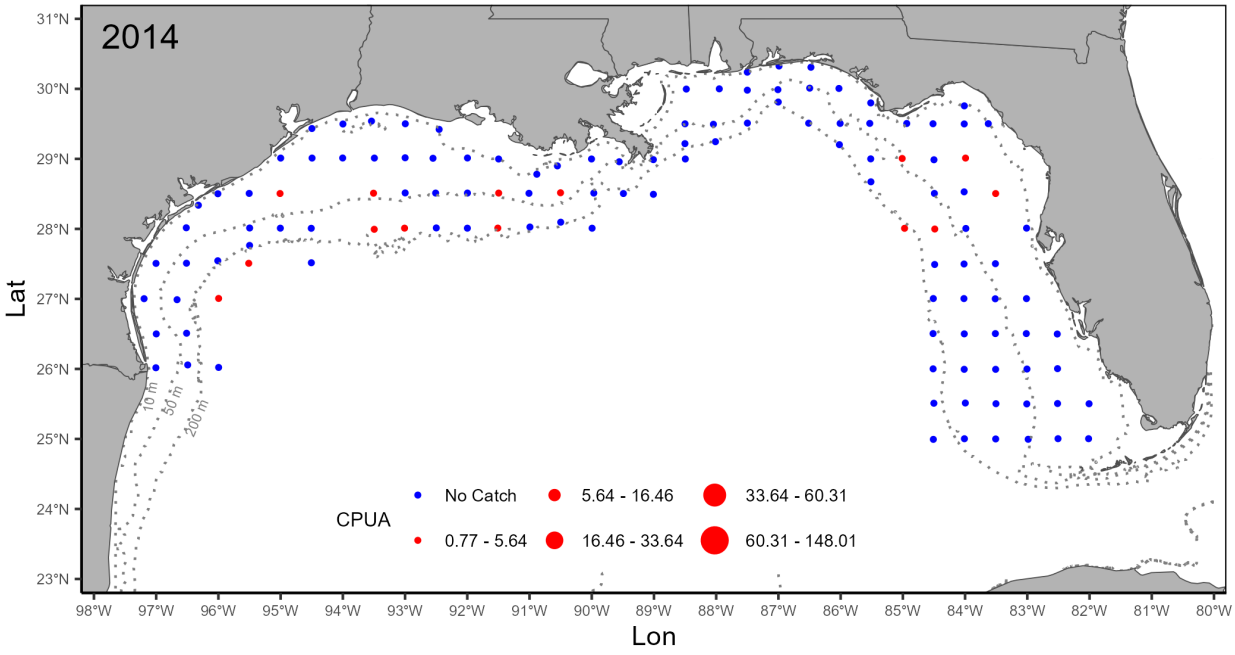
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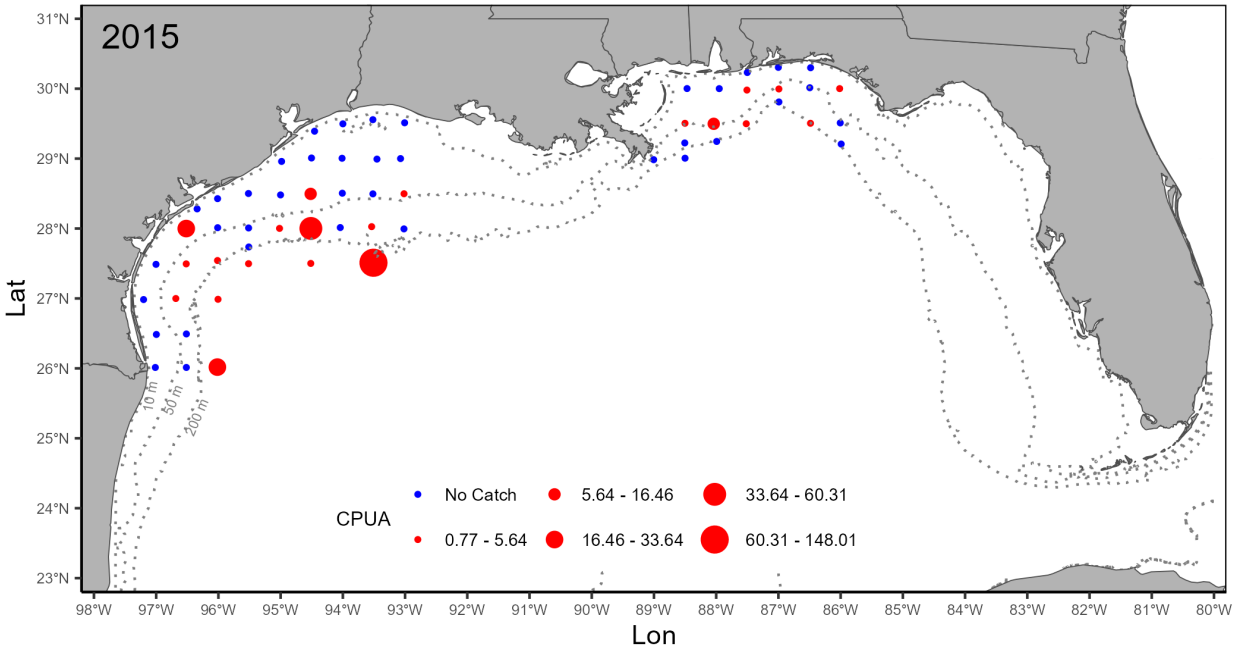
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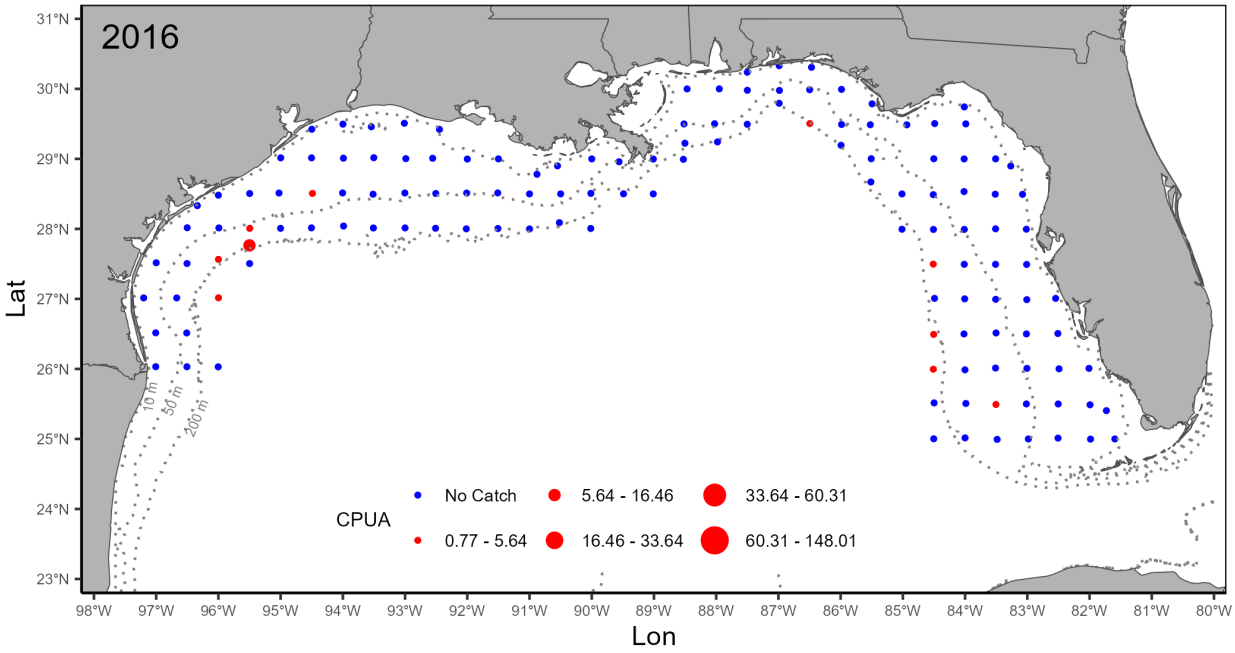
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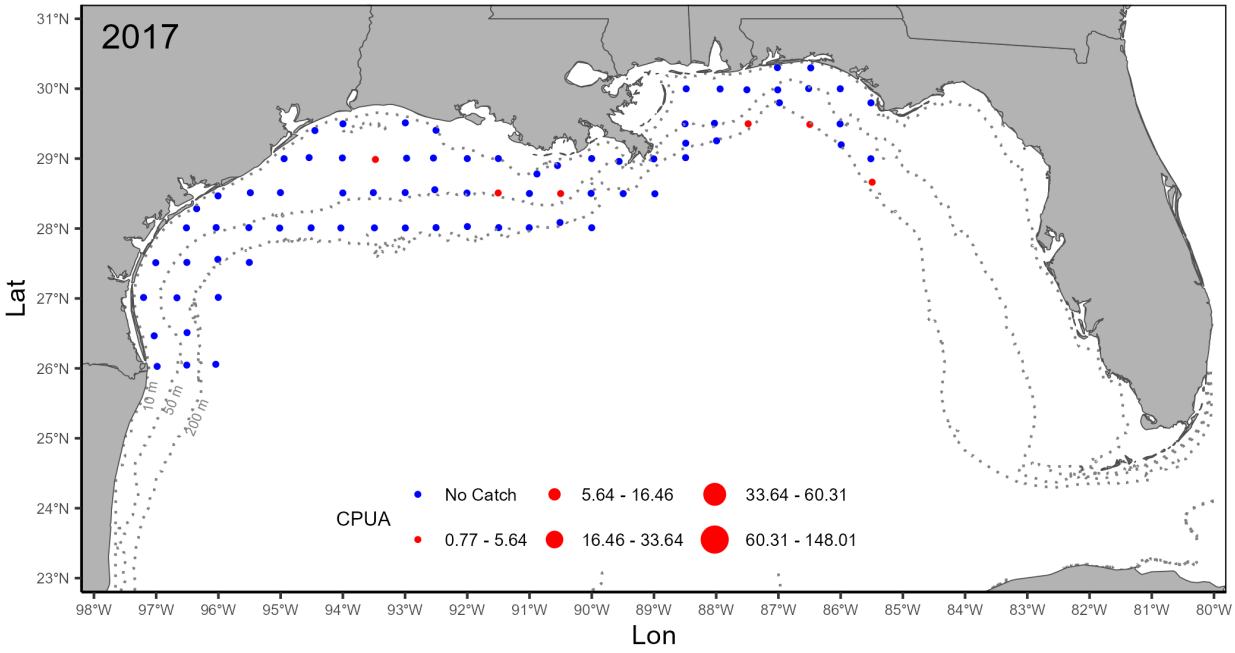
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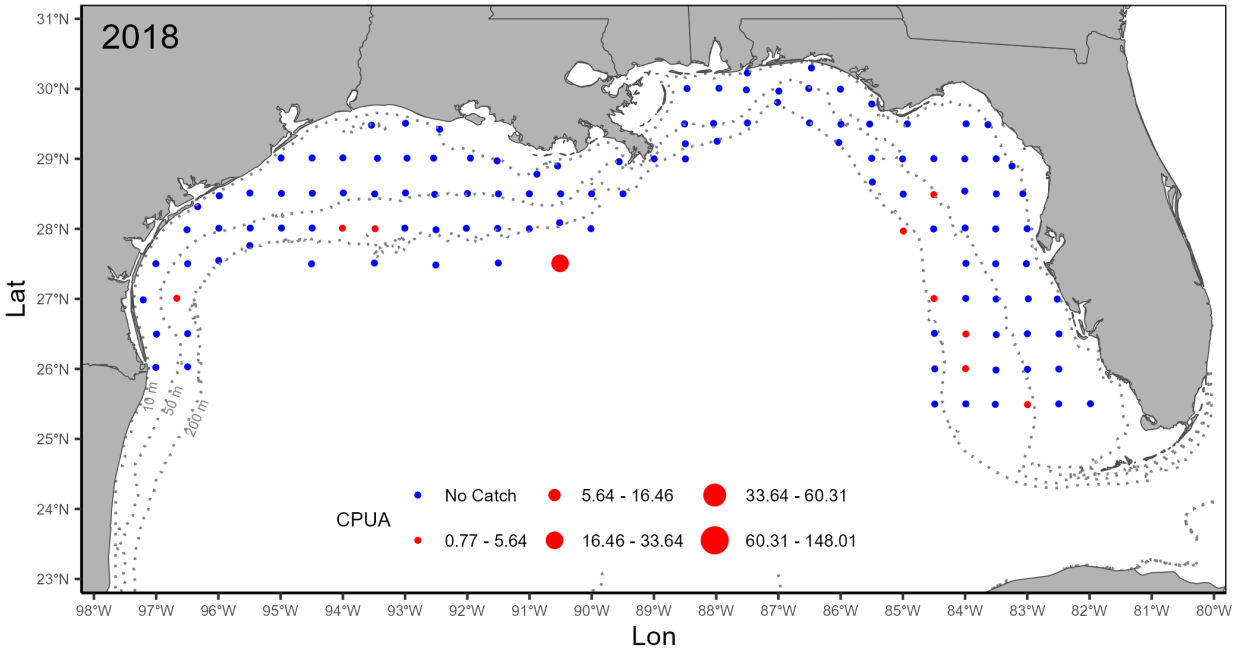
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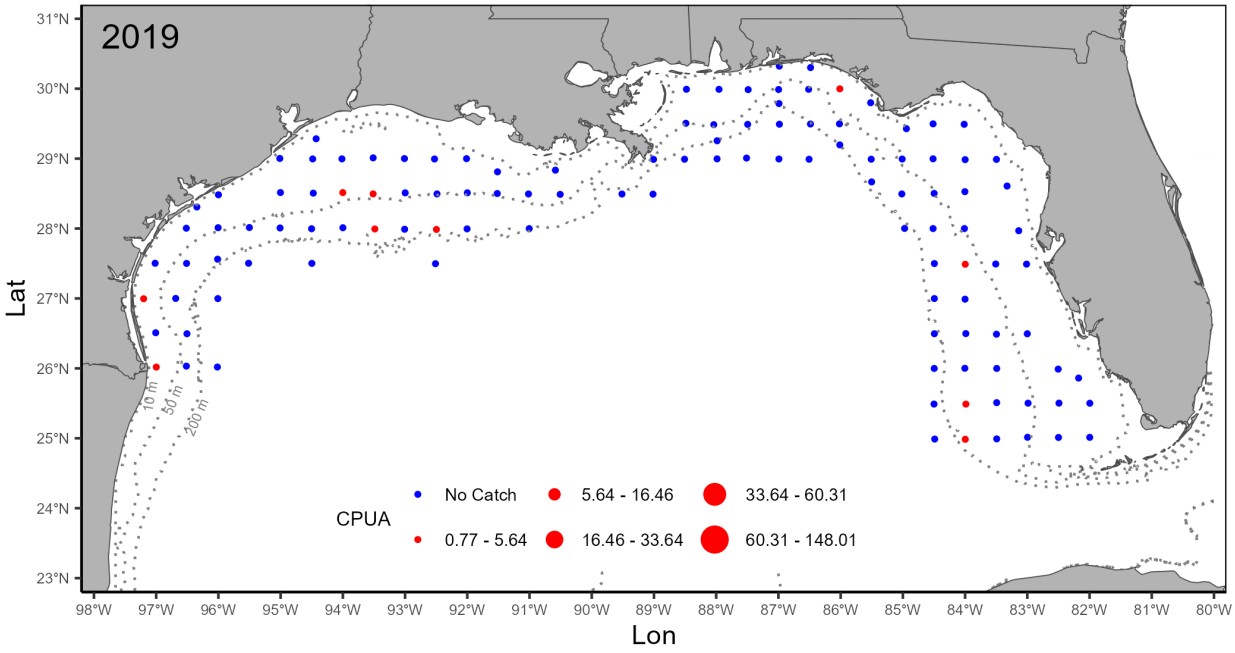
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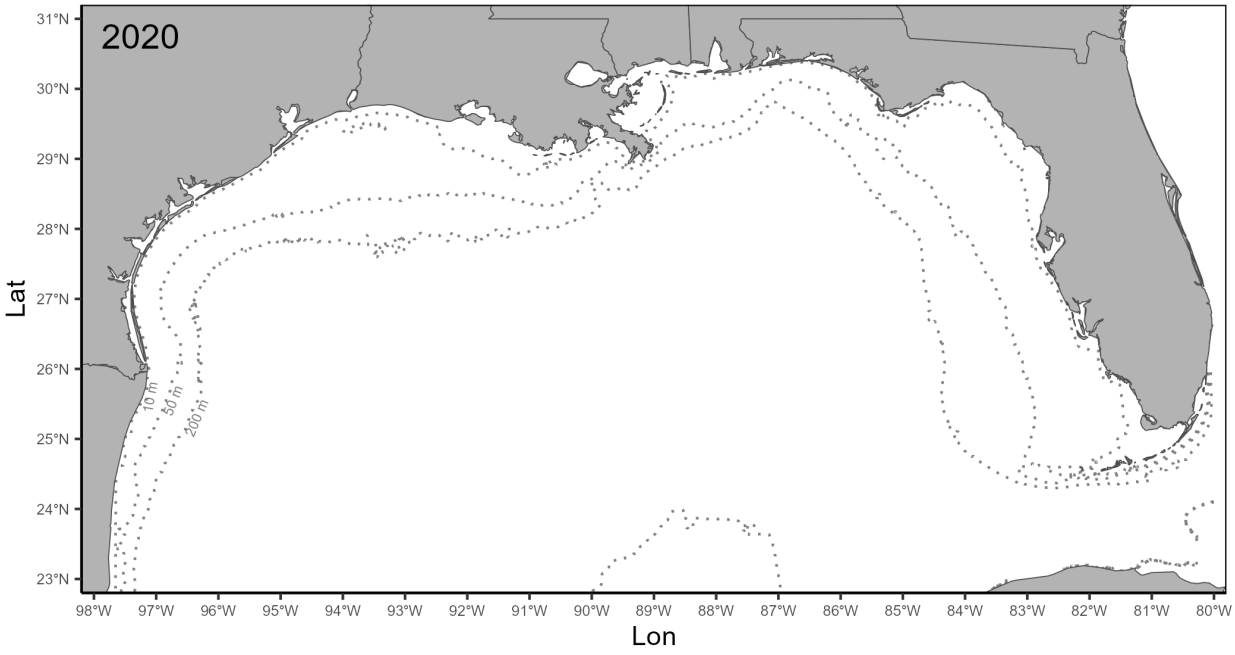
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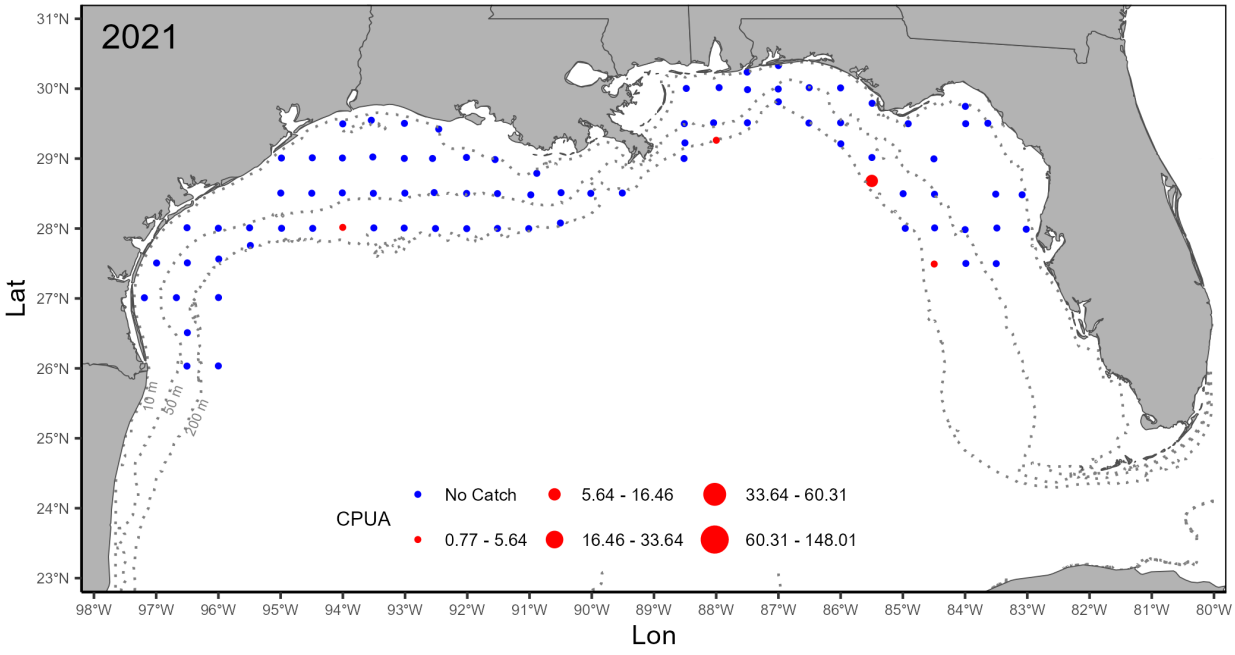
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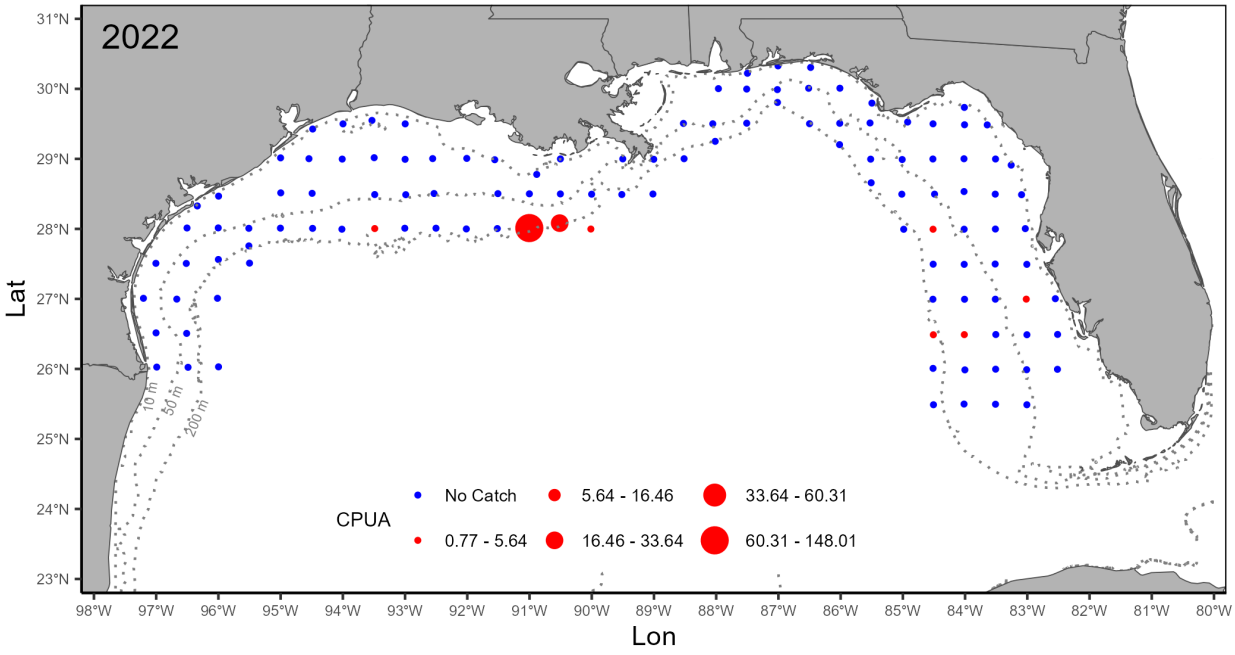
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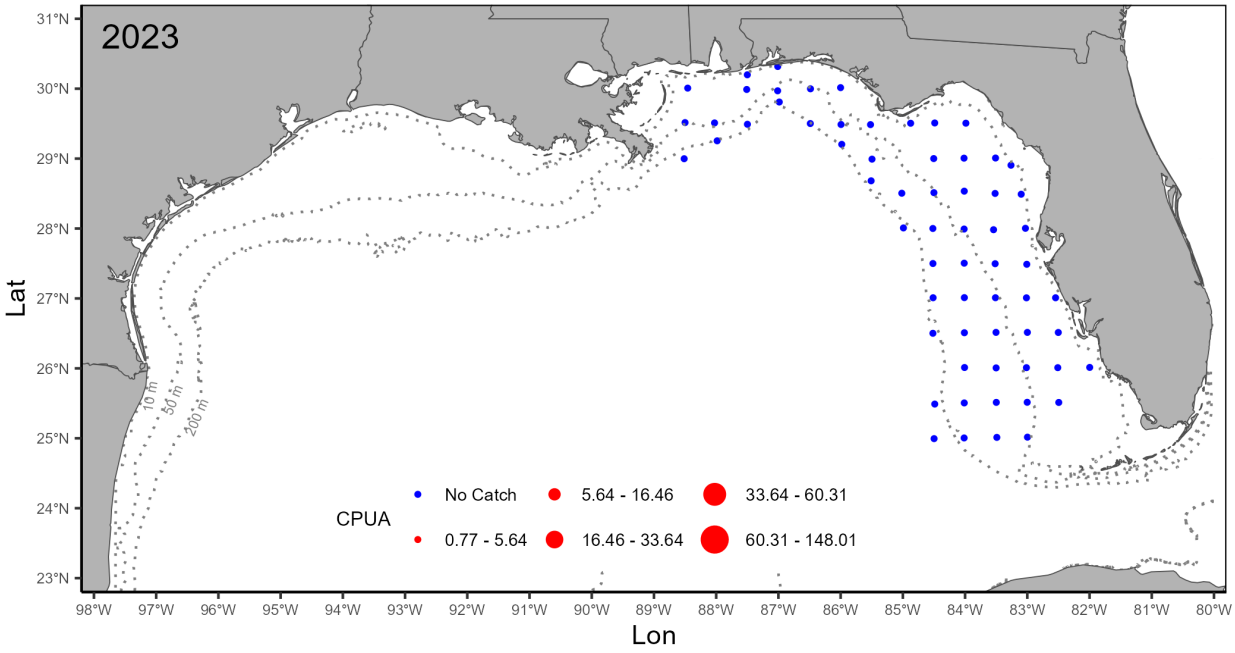
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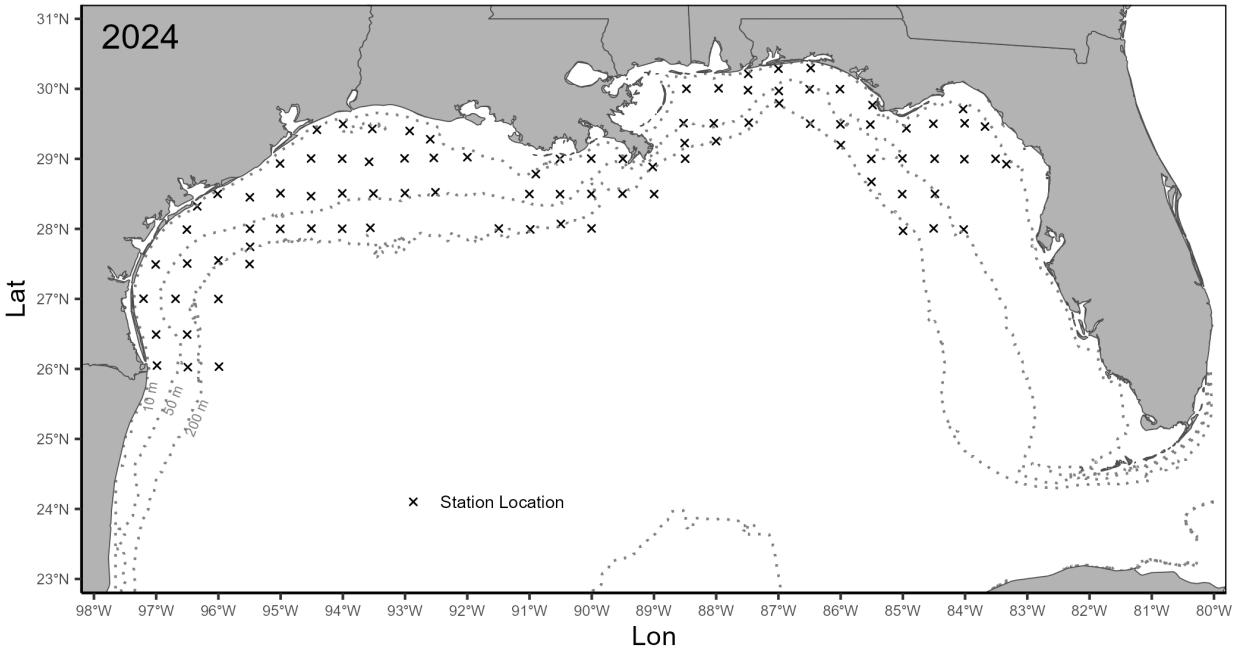
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Station Location