Analysis of SEAMAP-C hook and line survey data for yellowtail snapper in Puerto Rico (1992-2020)

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Introduction and Methodology

SEAMAP (Southeast Area Monitoring and Assessment Program) is a State/Federal/university program for collection, management and dissemination of fishery-independent data and information in the southeastern United States. This long-term fishery independent monitoring includes three operational areas, the Gulf of Mexico, the South-Atlantic and the Caribbean (Puerto Rico and the US Virgin Islands). Each area operates independently, following cooperatively established administrative policies and guidelines defined by its management units. Funding comes from the US Congress allocated budget, based on approved multi-year cooperative agreements.

The SEAMAP-C or SEAMAP Caribbean Survey is aimed at determining abundance and seasonal fluctuations of commercially exploited species in selected areas. Its administration and collective decisions are taken by a group of partners: the Puerto Rico Department of Natural and Environmental Resources (DNRA), U.S. Virgin Islands Department of Planning and Natural Resources (DPNR), Caribbean Fishery Management Council (CFMC), University of Puerto Rico, Puerto Rico Sea Grant College Program (UPRSGCP), NMFS Southeast Fisheries Science Center (SEFSC) , US Fish & Wildlife Service (FWS), and the University of the Virgin Islands (UVI).

Recently, all the available SEAMAP-C finfish data from the Caribbean components (U.S. Virgin Islands and Puerto Rico) since its inception in 1989 through 2022 have been archived into a “Gold Copy.” These fishery-independent data were collected through survey methods that include trap fishing, and hook and line data. These surveys were performed as part of the SEAMAP-C, which has been carrying out fishery-independent surveys since 1988 in the southwest coast of Puerto Rico (PR) and the coast of St. Thomas, St. Croix and St. John (U.S. Virgin Islands – USVI). The data acquired are intended to be used for long-term assessments and monitoring of the status of the local fisheries, including population abundances, recruitment, and ecological relationships. This information can be used to ascertain trends, determine potential causes of changes, and react responsibly to address them, for a more effective regulatory fisheries management program. For references of this SEAMAP-C data and discussions/descriptions of survey methodologies, please see the following: Anonymous 2014; Cass-Calay et al. 2016; Anonymous 2017.

The datasets for PR were provided by the SEAMAP-C components and consisted of five Sampling Programs extending from 1992-2020 (Tables 1 & 2). During each of these Sampling Programs, hook and line methodologies differed to align with the different priorities of each program. The reef fish survey officially began in 1992 as a SEAMAP survey in PR. Until 2004, sampling was conducted using two gears: hook-and-line and fish traps. The use of fish traps ceased in 2006, and hook-and-line is now the primary gear used for this survey. In 2016, the reef fish survey was revamped and expanded to include video and bottom longline to complement the hook-and-line gear. Table 3 lists the various hook and line sampling methods by Sampling Program. This includes number of lines used, number of hooks per line, number of gear immersions, total sampling time, hook type used, and whether the vessel was set to drifting or anchored during sampling. During the Pilot I sampling program, there was a transition from the vessel drifting to being anchored; and stations were conducted alternating between these two methods. This was done so station locations can be associated with a specific habitat during future surveys. During the Reef Fish I, Snapper I and Snapper II sampling programs, stations were randomly selected from of 2 x 2 nautical miles quadrats off the west and east insular shelves. During the Pilot I and Reef Fish II sampling programs, sample site selection for the Pilot I and Reef Fish II Sampling Programs included a two-factor

random stratified sampling design based on depth and benthic habitat type within the 50-fathom contour of eastern and western PR. During all Sampling Programs, all yellowtail snapper (YTS) were counted, weighed and measured.

These SEAMAP-C data were analyzed to determine if there exists trends in abundance for YTS in eastern and western PR and both areas combined. The analyses focused on hook and line survey data, since it contained the largest number of samples of the longest series of time. In order to calculate the CPUE of YTS collected by hook and line surveys from PR, the number of YTS were divided by the product of the number of lines per vessel, the number of hooks per line, and the time spent sampling. Due to the differences in methodologies and research focus between Sampling Programs, resulting effort estimations were very different. In addition, these differing methodologies are confounded in time. The CPUE data were standardized before employing the delta-lognormal model, by first calculating the CPUE as above, and then standardize that CPUE to a mean of one within each Sampling Program. The variables employed in the delta-lognormal model (Lo et al. 1992) included year, quarter, position method (i.e. anchored or drifting), hook type (J or C) and survey area (east or west PR) for the combined model. Models were constructed using a backward selection procedure, based on Type 3 tests of significance, and residual analyses were used to determine model performance. Finally, length frequencies for all specimens combined, by gear year (i.e. hook and line, longline, and trap), by year, and by gear and are provided.

Results and Discussion

Figure 1 is a chart of all hook and line survey stations used in this analysis. Tables 4 – 9 show the backward selection results of model selection for the binomial and lognormal submodels for eastern and western PR and both areas combined, respectively. Figures 2 – 7 show the residual analysis results for binomial and lognormal submodels for eastern and western PR and both areas combined, respectively. Tables 10 – 12 and Figures 8 – 10 summarize the time series of hook and line indices for eastern and western PR and both areas combined, respectively. Length-frequency histograms are presented by for all specimens combined, by gear, by year, and by gear and year, respectively.

Due to the changes in methodologies and research focus between Sampling Programs being confounded in time, the standardization technique of scaling the CPUE to a mean of one within each Sampling Program could mask changes in abundance trends. These results should only be accepted with caution. Likewise, length frequency distributions are subject to survey gear catchability, and differing catchabilities during each sampling program and with each gear type, could confuse any trends in fish size.

Literature Cited

Anonymous. 2014. Annual Report of the Southeast Area Monitoring and Assessment Program (SEAMAP): October 1, 2012 - September 30, 2013. Gulf States Marine Fisheries Commission. Number 223, February 2014. 20 pages.

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Table 1. Beginning and ending dates of SEAMAP-C Sampling Programs in Puerto Rico, all areas combined.

Sampling Program	*Number of Stations*	*Start Date*	*End Date*
Reef fish I	672	17SEP1991	15MAR2006
Snapper I	291	04MAR2009	20AUG2012
Snapper II	238	08JAN2013	29OCT2015
Pilot I	282	02FEB2016	29MAR2017
Reef fish II	377	01MAR2018	08SEP2020

Table 2. Beginning and ending dates of SEAMAP-C Sampling Programs in Puerto Rico by sampling area.

Sampling Area	*Sampling Program*	*Number of Stations*	*Start Date*	*End Date*
Eastern	Snapper I	154	20OCT2009	20AUG2012
Eastern	Snapper II	103	22JAN2013	29OCT2015
Eastern	Pilot I	159	02FEB2016	29MAR2017
Eastern	Reef fish II	69	26JUN2019	08SEP2020
Western	Reef fish I	672	17SEP1991	15MAR2006
Western	Snapper I	137	04MAR2009	31MAR2011
Western	Snapper II	135	08JAN2013	22DEC2014
Western	Pilot I	123	19DEC2016	14FEB2017
Western	Reef fish II	308	01MAR2018	28MAR2019

Table 3. Methodological differences between Sampling Programs.

Sampling program	Number of lines per vessel	Number of hooks per line	Average Sampling Time (hours:minutes)	Hook Type	Position Method
Reef fish I	3	3	4:26	J	Drifting
Snapper I	3	2	3:16	J	Drifting
Snapper II	3	3	4	J	Drifting
Pilot I	3	4	1:11	J	Drifting/Anchored
Reef fish II	3	2	0:10	J/C	Anchored

Table 4. Type 3 significance tests for binomial submodel parameter significance for eastern Puerto Rico.

LR Statistics For Type 3 Analysis, Run=1			
Source	*DF*	*Chi-Square*	*Pr > ChiSq*
Year	9	73.41	<.0001
Quarter	3	1.57	0.6660
Hook Type	1	0.95	0.3308
Vessel Method	1	4.76	0.0291
LR Statistics For Type 3 Analysis, Run=2			
Source	*DF*	*Chi-Square*	*Pr > ChiSq*
Year	9	82.16	<.0001
Quarter			dropped
Hook Type	1	0.92	0.3366
Vessel Method	1	4.83	0.0280
LR Statistics For Type 3 Analysis, Run=3			
Source	*DF*	*Chi-Square*	*Pr > ChiSq*
Year	9	85.01	<.0001
Quarter			dropped
Hook Type			dropped
Vessel Method	1	4.83	0.0280

Table 5. Type 3 significance tests for lognormal submodel parameter significance for eastern Puerto Rico.

Type III Tests of Fixed Effects, Run=1				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	9	124	20.04	<.0001
Quarter	3	124	1.61	0.1909
Hook Type	1	124	0.22	0.6389
Vessel Method	1	124	7.65	0.0065
Type III Tests of Fixed Effects, Run=2				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	9	125	20.14	<.0001
Quarter	3	125	1.60	0.1929
Hook Type				dropped
Vessel Method	1	125	7.69	0.0064
Type III Tests of Fixed Effects, Run=3				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	9	128	22.92	<.0001
Quarter				dropped
Hook Type				dropped
Vessel Method	1	128	7.89	0.0058

Table 6. Type 3 significance tests for binomial submodel parameter significance for western Puerto Rico.

LR Statistics For Type 3 Analysis, Run=1			
Source	*DF*	*Chi-Square*	*Pr > ChiSq*
Year	18	296.52	<.0001
Quarter	3	11.00	0.0117
Hook Type	1	0.09	0.7634
Vessel Method	1	0.49	0.4818
LR Statistics For Type 3 Analysis, Run=2			
Source	*DF*	*Chi-Square*	*Pr > ChiSq*
Year	18	296.54	<.0001
Quarter	3	11.01	0.0117
Hook Type			dropped
Vessel Method	1	0.49	0.4818
LR Statistics For Type 3 Analysis, Run=3			
Source	*DF*	*Chi-Square*	*Pr > ChiSq*
Year	18	323.27	<.0001
Quarter			dropped
Hook Type			dropped
Vessel Method	3	11.01	0.0117

Table 7. Type 3 significance tests for lognormal submodel parameter significance for western Puerto Rico.

Type III Tests of Fixed Effects, Run=1				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	18	202	11.10	<.0001
Quarter	3	202	0.76	0.5198
Hook Type	1	202	0.00	0.9907
Vessel Method	1	202	0.03	0.8623
Type III Tests of Fixed Effects, Run=2				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	18	203	11.15	<.0001
Quarter	3	203	0.76	0.5176
Hook Type				dropped
Vessel Method	1	203	0.03	0.8620
Type III Tests of Fixed Effects, Run=3				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	18	204	11.28	<.0001
Quarter				dropped
Hook Type				dropped
Vessel Method	3	204	0.76	0.5155
Type III Tests of Fixed Effects, Run=4				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	18	207	12.30	<.0001
Quarter				dropped
Hook Type				dropped
Vessel Method				dropped

Table 8. Type 3 significance tests for binomial submodel parameter significance for eastern and western Puerto Rico combined.

LR Statistics For Type 3 Analysis, Run=1			
Source	*DF*	*Chi-Square*	*Pr > ChiSq*
Year	21	270.93	<.0001
Quarter	3	18.96	0.0003
Survey Area	1	18.44	<.0001
Hook Type	1	1.19	0.2752
Vessel Method	1	1.71	0.1915
LR Statistics For Type 3 Analysis, Run=2			
Source	*DF*	*Chi-Square*	*Pr > ChiSq*
Year	21	272.77	<.0001
Quarter	3	19.14	0.0003
Survey Area	1	18.24	<.0001
Hook Type			dropped
Vessel Method	1	1.71	0.1916
LR Statistics For Type 3 Analysis, Run=3			
Source	*DF*	*Chi-Square*	*Pr > ChiSq*
Year	21	276.77	<.0001
Quarter	3	19.17	0.0003
Survey Area	1	18.19	<.0001
Hook Type			dropped
Vessel Method			dropped

Table 9. Type 3 significance tests for lognormal submodel parameter significance for eastern and western Puerto Rico combined.

Type III Tests of Fixed Effects, Run=1				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	21	337	12.26	<.0001
Quarter	3	337	2.94	0.0331
Survey Area	1	337	34.50	<.0001
Hook Type	1	337	0.00	0.9804
Vessel Method	1	337	5.35	0.0213
Type III Tests of Fixed Effects, Run=2				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	21	338	12.29	<.0001
Quarter	3	338	2.96	0.0324
Survey Area	1	338	34.68	<.0001
Hook Type				dropped
Vessel Method	1	338	5.37	0.0211
Type III Tests of Fixed Effects, Run=3				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	21	338	12.29	<.0001
Quarter	3	338	2.96	0.0324
Survey Area	1	338	34.68	<.0001
Hook Type				dropped
Vessel Method	1	338	5.37	0.0211

Table 10. The sample size modeled index (with 95% CL), nominal index, nominal frequency, and CV plotted by year for eastern Puerto Rico.

Year	N	Nominal Frequency	Nominal Index	Index	LCL	UCL	CV
2009	21	0.19048	0.00498	0.00796	0.00276	0.02294	0.56833
2010	53	0.13208	0.00276	0.00489	0.00204	0.01175	0.45973
2011	14	0	0	0	0	0	
2012	66	0.33333	0.4612	0.42529	0.25833	0.70017	0.25319
2013	71	0.02817	0.01868	0.0307	0.0069	0.1366	0.86361
2014	17	0.05882	0.01561	0.02251	0.00355	0.14292	1.16153
2015	15	0.73333	0.90204	0.95439	0.56547	1.61082	0.26626
2016	13	0.69231	0.39819	0.32073	0.17716	0.58067	0.30345
2017	146	0.46575	0.49194	0.3604	0.27908	0.46541	0.12838
2018	0						
2019	34	0.20588	0.19608	0.11488	0.04624	0.28543	0.47965
2020	35	0.22857	0.2381	0.13905	0.05891	0.3282	0.44996

Table 11. The sample size modeled index (with 95% CL), nominal index, nominal frequency, and CV plotted by year for western Puerto Rico.

Year	N	Nominal Frequency	Nominal Index	index	LCL	UCL	CV
1991	35	0	0	0	0	0	
1992	111	0.02703	0.02402	0.02417	0.00667	0.08751	0.71606
1993	141	0.04965	0.04413	0.0444	0.01809	0.10897	0.47256
1994	120	0.04167	0.04444	0.03942	0.01386	0.11212	0.56044
1995	35	0.08571	0.07619	0.06754	0.01844	0.24731	0.72371
1996	0						
1997	56	0.01786	0.01587	0.01275	0.00191	0.08504	1.20846
1998	13	0	0	0	0	0	
1999	9	0.11111	0.09877	0.09815	0.01575	0.61154	1.1441
2000	33	0.18182	0.26936	0.21826	0.08415	0.56607	0.50489
2001	29	0.06897	0.0613	0.04755	0.01038	0.21774	0.88535
2002	0						
2003	0						
2004	15	0	0	0	0	0	
2005	59	0.0678	0.0678	0.07864	0.02547	0.24278	0.61151
2006	16	0.0625	0.125	0.08294	0.01243	0.55359	1.20902
2007	0						
2008	0						
2009	67	0.26866	0.01478	0.01692	0.00988	0.02897	0.274
2010	47	0.68085	1.04724	0.63335	0.45029	0.89082	0.17181
2011	23	0.82609	1.08404	0.80818	0.52941	1.23375	0.2139
2012	0						
2013	94	0.53191	0.54044	0.3996	0.29861	0.53473	0.14643
2014	41	0.53659	0.49692	0.33829	0.21863	0.52344	0.22088
2015	0						
2016	39	0.28205	0.15563	0.08438	0.03703	0.19229	0.4299
2017	84	0.17857	0.21296	0.15593	0.07718	0.31502	0.36277
2018	88	0.13636	0.15593	0.07947	0.03481	0.18145	0.431
2019	220	0.06364	0.05581	0.04719	0.02217	0.10046	0.39164

Table 12. The sample size modeled index (with 95% CL), nominal index, nominal frequency, and CV plotted by year for eastern and western Puerto Rico combined.

Year	N	Nominal Frequency	Nominal Index	Index	LCL	UCL	CV
1991	35	0	0	0	0	0	
1992	111	0.02703	0.02402	0.01285	0.00336	0.04922	0.75477
1993	141	0.04965	0.04413	0.02555	0.00971	0.06717	0.51305
1994	120	0.04167	0.04444	0.02099	0.00691	0.06373	0.60114
1995	35	0.08571	0.07619	0.058	0.01521	0.22115	0.75157
1996	0	.					
1997	56	0.01786	0.01587	0.00474	0.00068	0.03291	1.2477
1998	13	0	0	0	0	0	
1999	9	0.11111	0.09877	0.06296	0.00936	0.42329	1.21611
2000	33	0.18182	0.26936	0.10686	0.03743	0.30508	0.56276
2001	29	0.06897	0.0613	0.04614	0.00974	0.21867	0.91185
2002	0						
2003	0						
2004	15	0	0	0	0	0	
2005	59	0.0678	0.0678	0.04369	0.01315	0.14515	0.65873
2006	16	0.0625	0.125	0.07791	0.01137	0.53391	1.23481
2007	0						
2008	0						
2009	88	0.25	0.01244	0.01005	0.00575	0.01755	0.28428
2010	100	0.39	0.49366	0.15251	0.09907	0.23477	0.21822
2011	37	0.51351	0.67387	0.55166	0.3065	0.99293	0.30032
2012	66	0.33333	0.4612	0.76174	0.45029	1.2886	0.26746
2013	165	0.31515	0.31593	0.23	0.15453	0.34232	0.20082
2014	58	0.39655	0.35584	0.16145	0.09269	0.28124	0.28292
2015	15	0.73333	0.90204	1.30665	0.71291	2.39491	0.31002
2016	52	0.38462	0.21627	0.0758	0.03795	0.15139	0.35648
2017	230	0.36087	0.39005	0.58618	0.39701	0.86549	0.1967
2018	88	0.13636	0.15593	0.02062	0.0085	0.05	0.4656
2019	254	0.08268	0.07458	0.05096	0.02684	0.09673	0.32889
2020	35	0.22857	0.2381	0.49542	0.21606	1.13598	0.43344

Figure 1. SEAMAP-C Hook and line survey sampling positions around Puerto Rico.

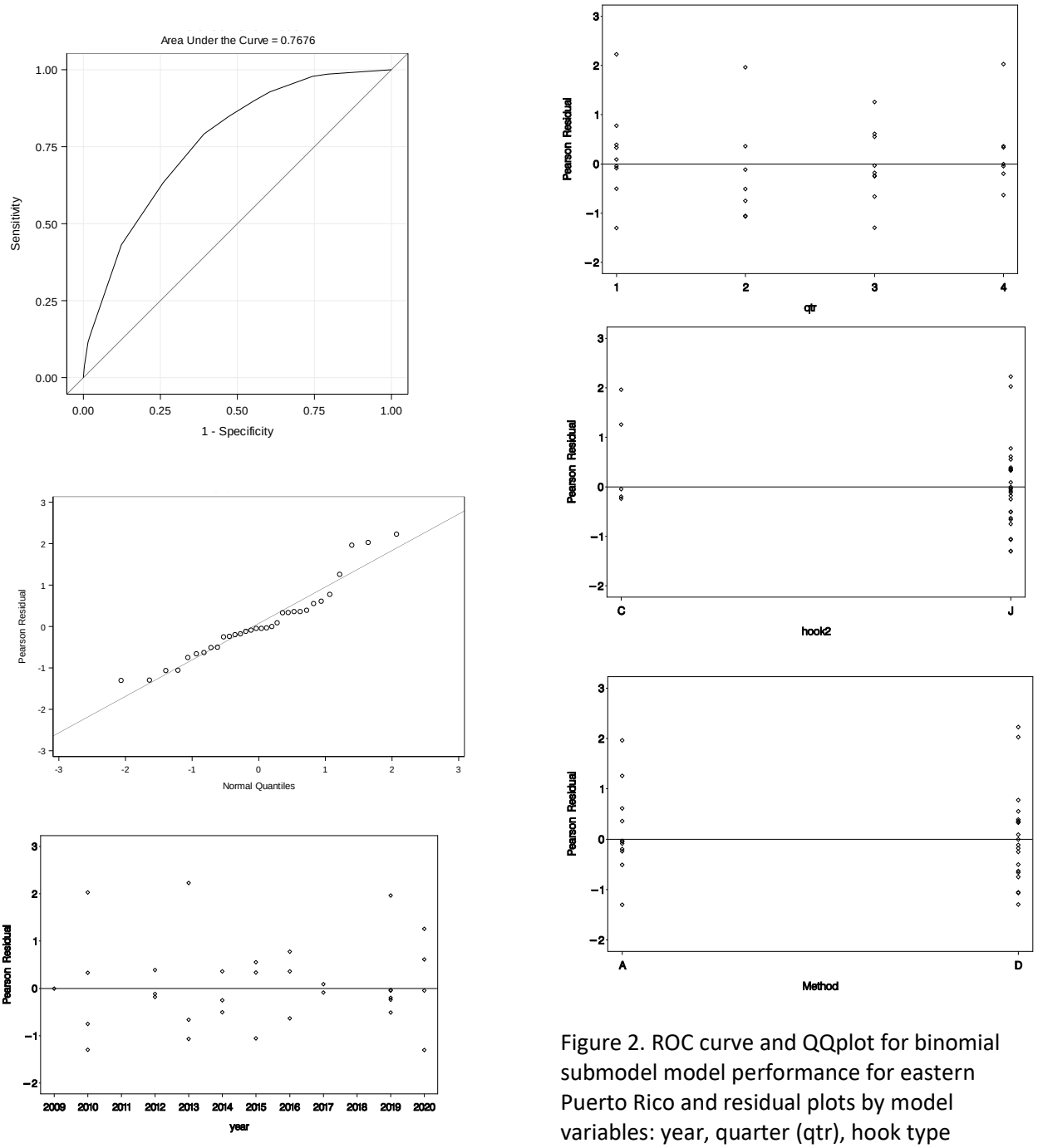


Figure 2. ROC curve and QQplot for binomial submodel model performance for eastern Puerto Rico and residual plots by model variables: year, quarter (qtr), hook type (C=circle; J=J-hook), and vessel method (A=anchored; D=drifting).

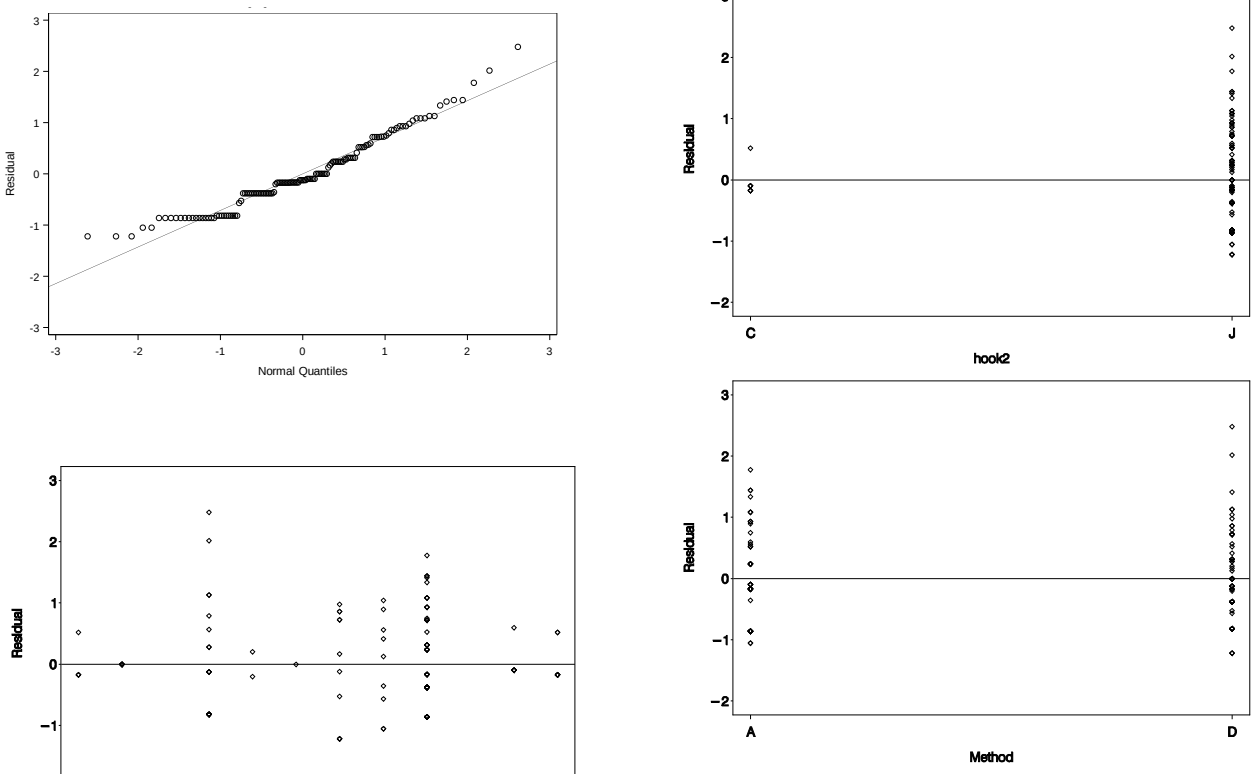
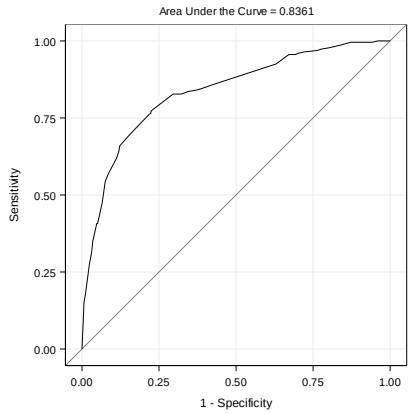
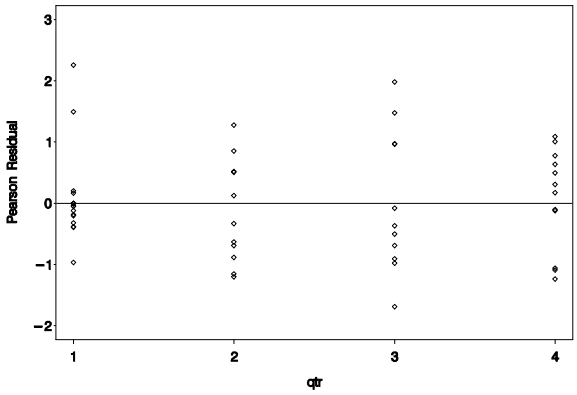
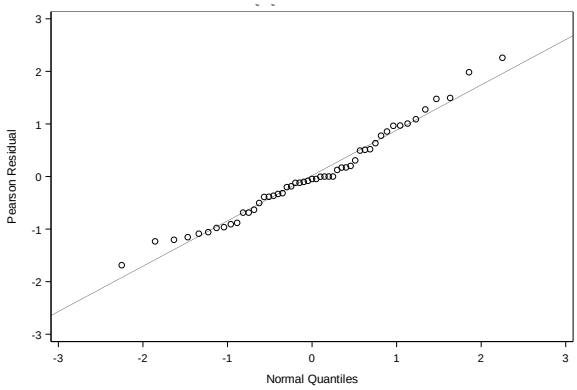


Figure 3. QQplot for lognormal submodel model performance for eastern Puerto Rico and residual plots by model variables: year, quarter (qtr), hook type (C=circle; J=J-hook), and vessel method (A=anchored; D=drifting).







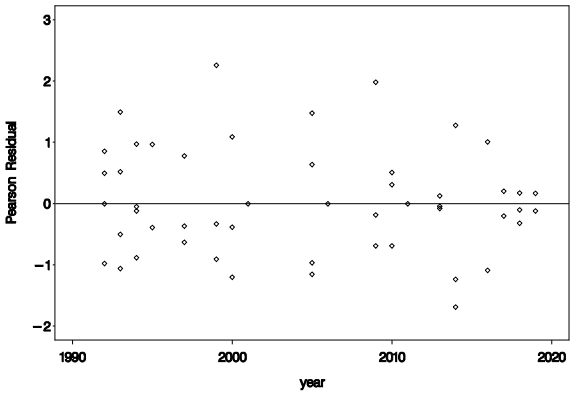


Figure 4. ROC curve and QQplot for binomial submodel model performance for western Puerto Rico and residual plots by model variables: year, quarter (qtr), hook type (C=circle; J=J-hook), and vessel method (A=anchored; D=drifting).

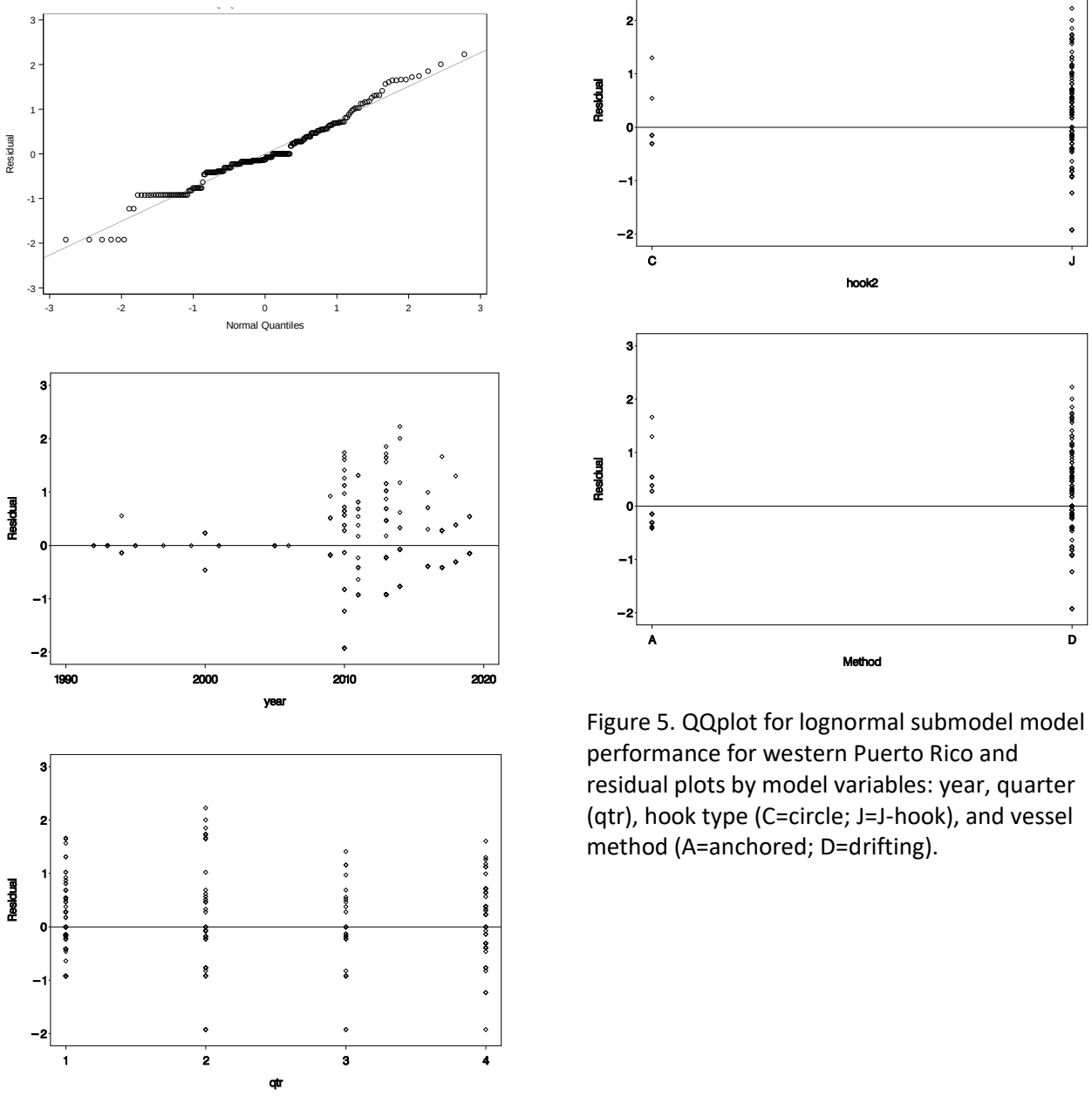


Figure 5. QQplot for lognormal submodel model performance for western Puerto Rico and residual plots by model variables: year, quarter (qtr), hook type (C=circle; J=J-hook), and vessel method (A=anchored; D=drifting).

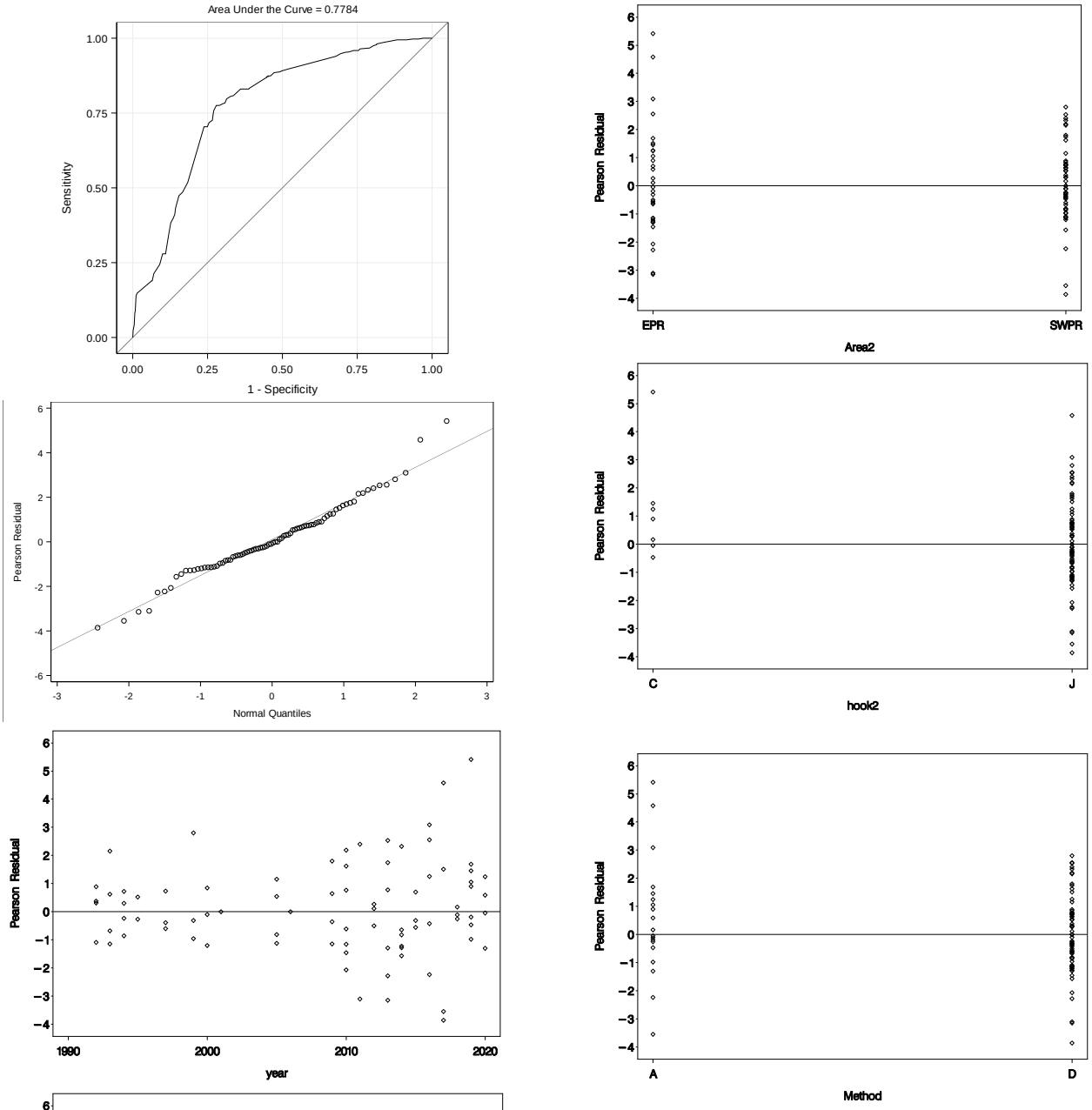
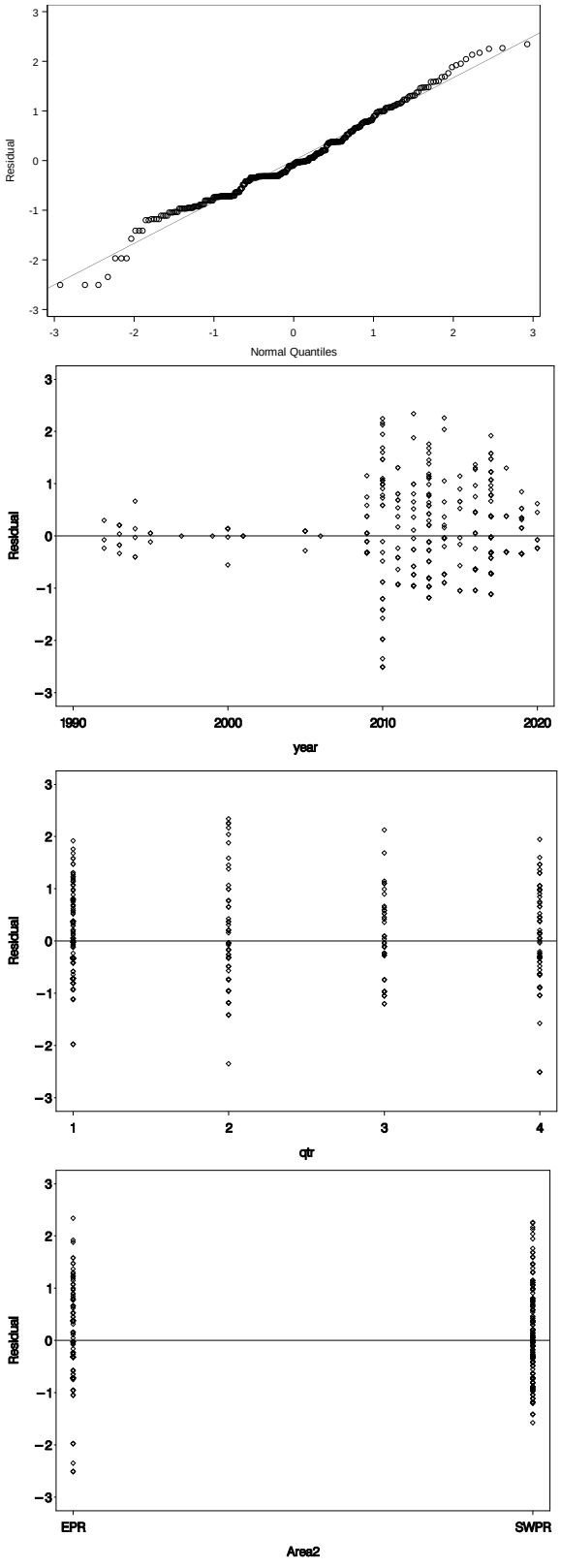


Figure 6. ROC curve and QQplot for binomial submodel model performance for eastern and western Puerto Rico combined and residual plots by model variables: year, quarter (qtr), survey area (EPR=eastern, SWPR=western), hook type (C=circle; J=J-hook), and vessel method (A=anchored; D=drifting).



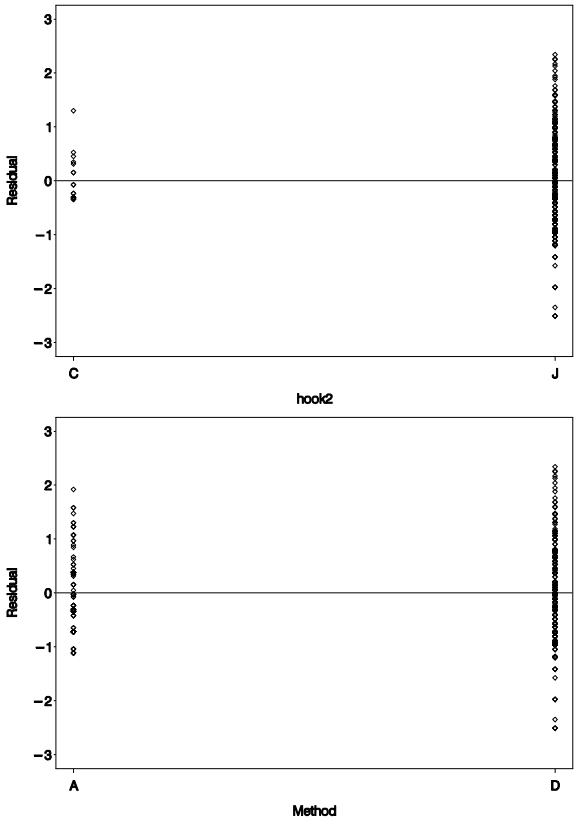


Figure 7. QQplot for lognormal submodel model performance for eastern and western Puerto Rico combined and residual plots by model variables: year, quarter (qtr), survey area (EPR=eastern, SWPR=western), hook type (C=circle; J=J-hook), and vessel method (A=anchored; D=drifting).

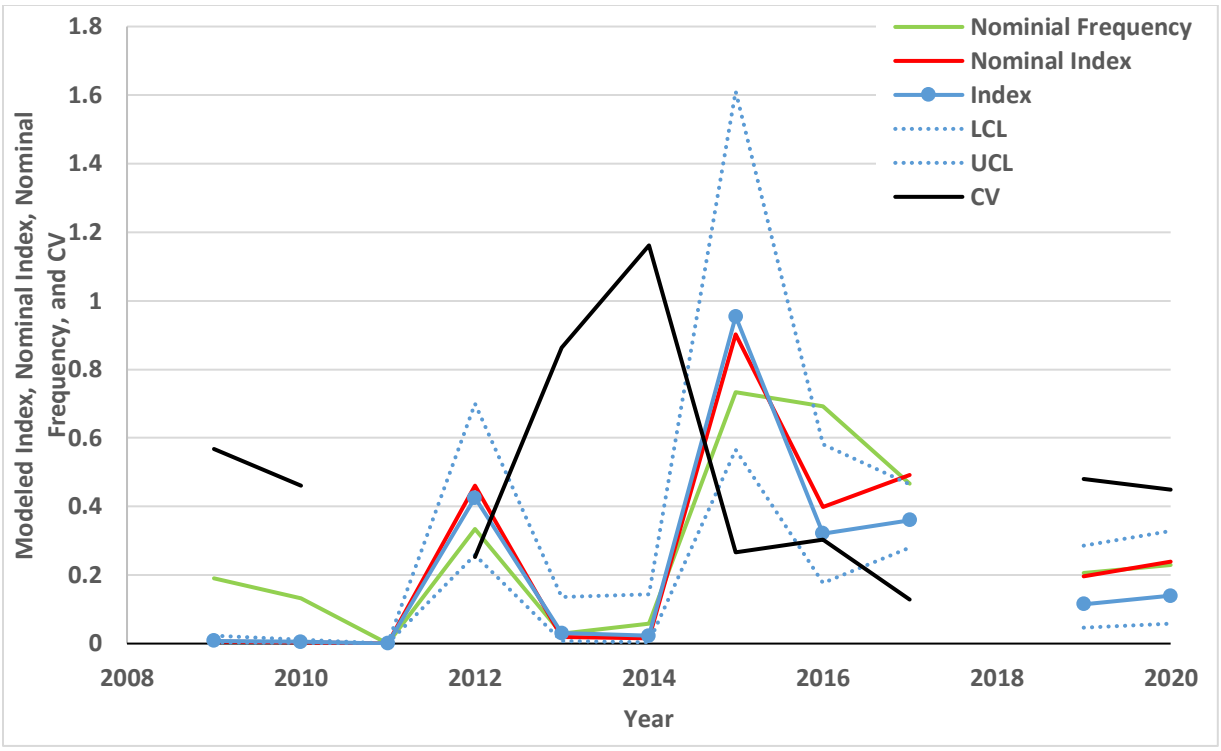


Figure 8. The modeled index (with 95% CL), nominal index, nominal frequency, and CV plotted by year for eastern Puerto Rico.

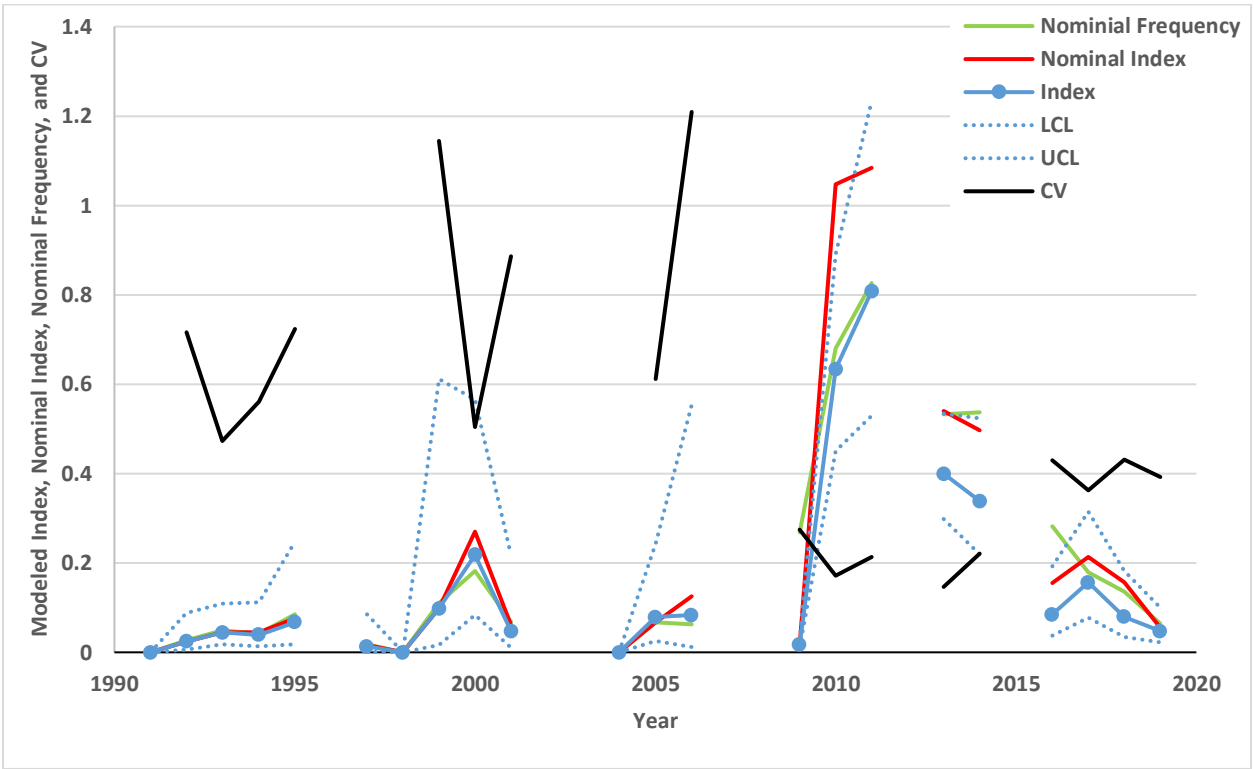


Figure 9. The modeled index (with 95% CL), nominal index, nominal frequency, and CV plotted by year for western Puerto Rico.

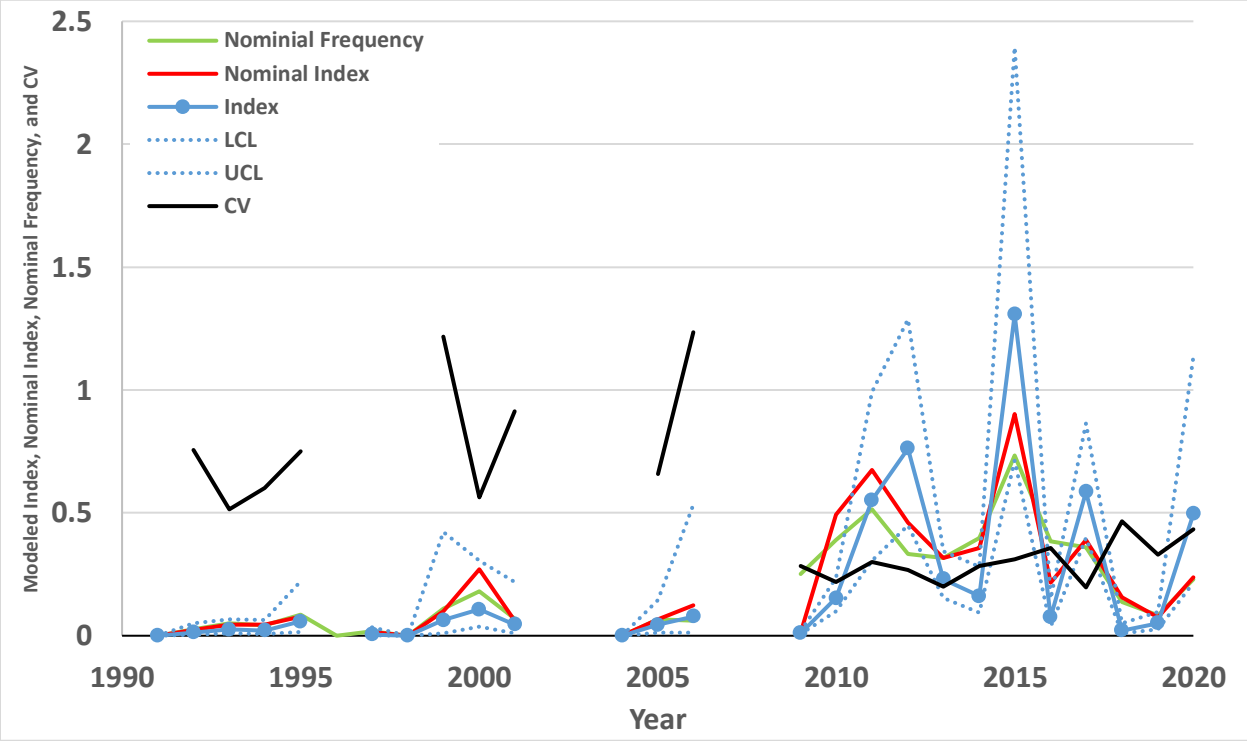
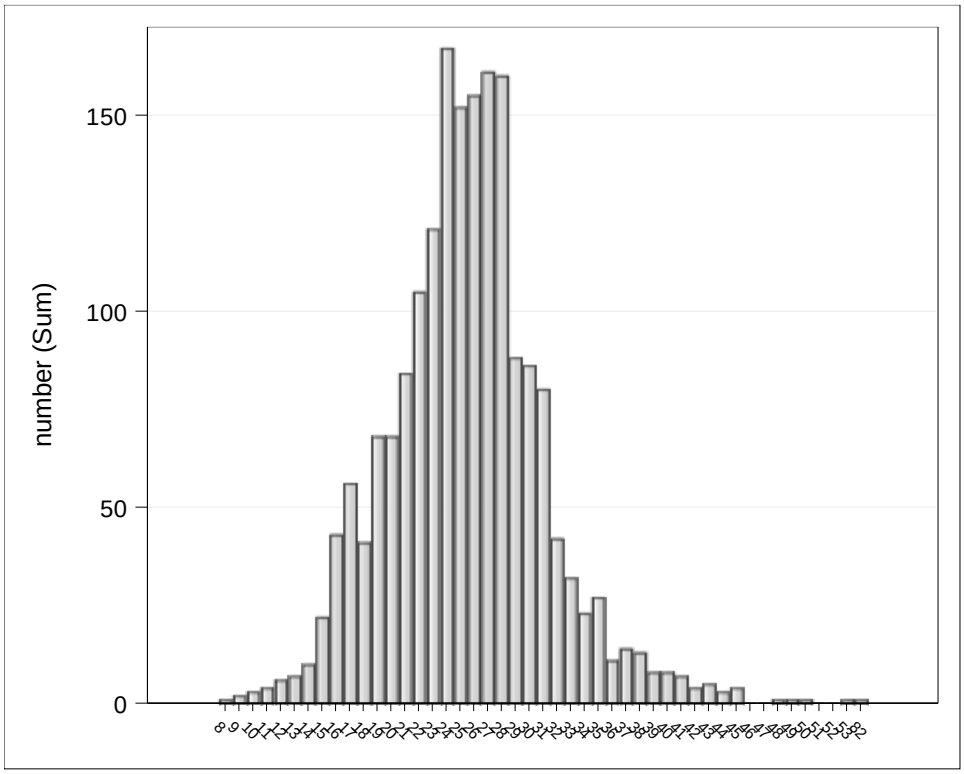


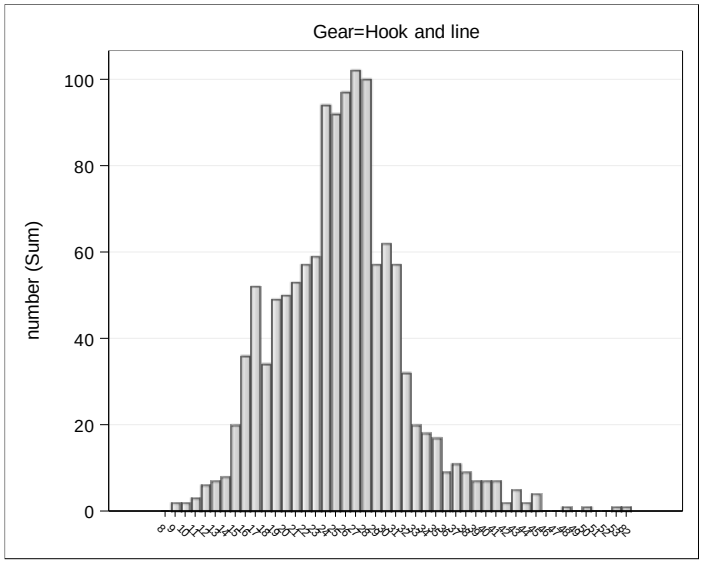
Figure 10. The modeled index (with 95% CL), nominal index, nominal frequency, and CV plotted by year for eastern and western Puerto Rico combined.

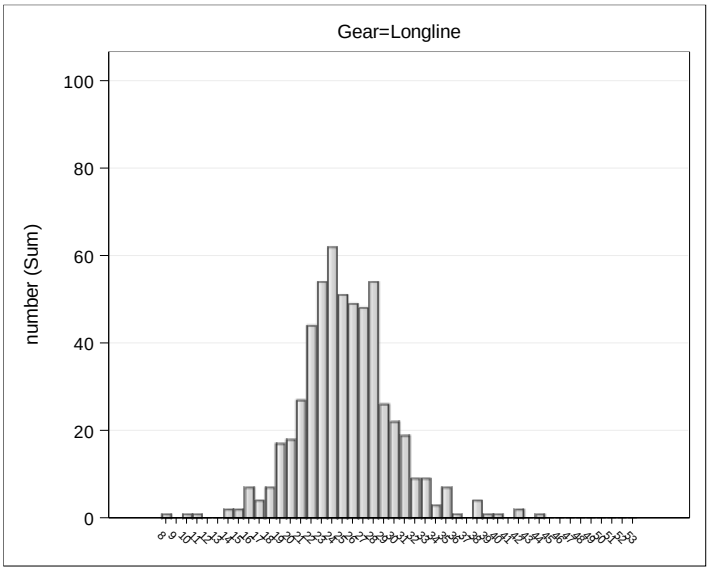
Length Frequency Histograms (number per cm-fork length)

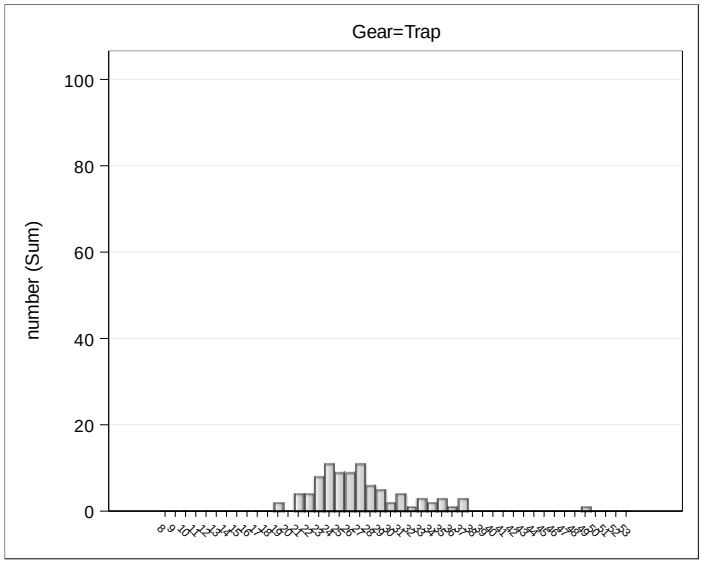
All Combined (N=1896)



By Gear (Hook and line, N=1253; Longline, N=554; Trap, N=89)

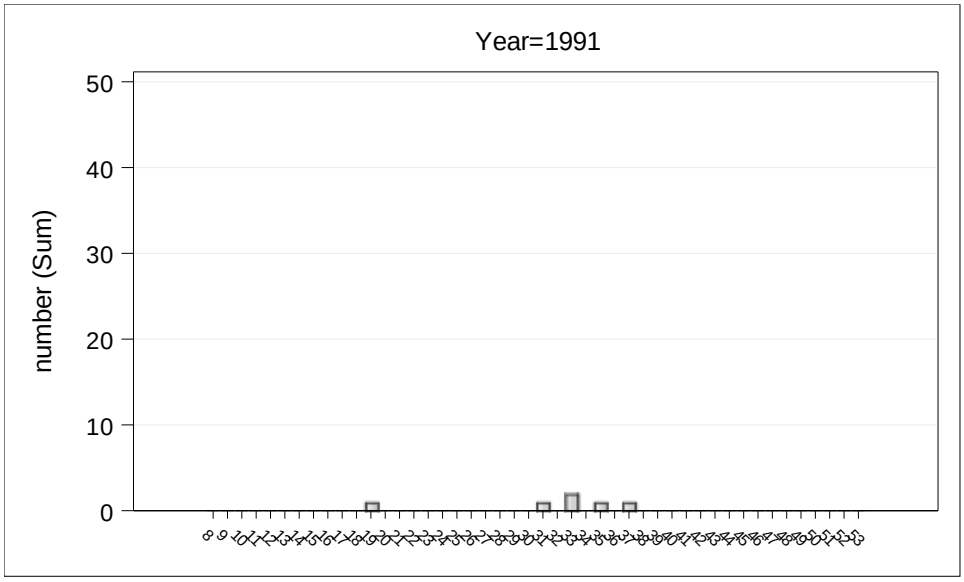






By Year

Year	*number*
1991	6
1992	14
1993	15
1994	8
1995	4
1997	1
1998	9
1999	14
2000	10
2001	2
2005	25
2006	14
2009	27
2010	328
2011	187
2012	333
2013	185
2014	78
2015	43
2016	44
2017	245
2018	101
2019	174
2020	29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20
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40
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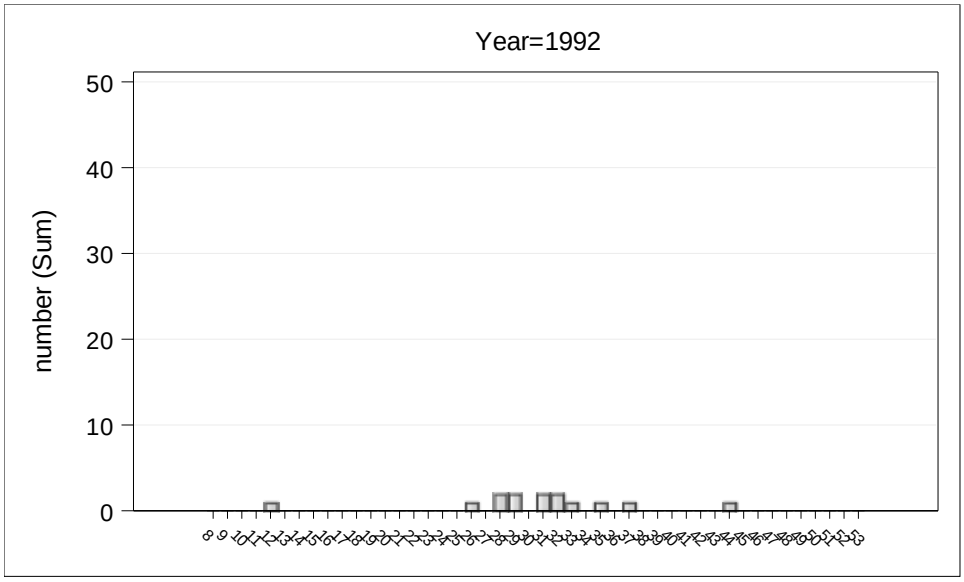
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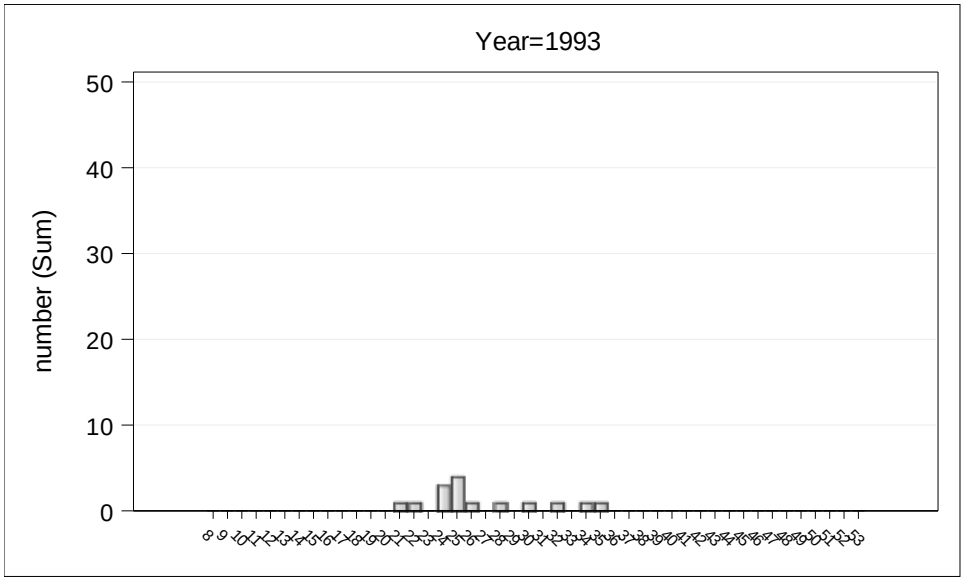
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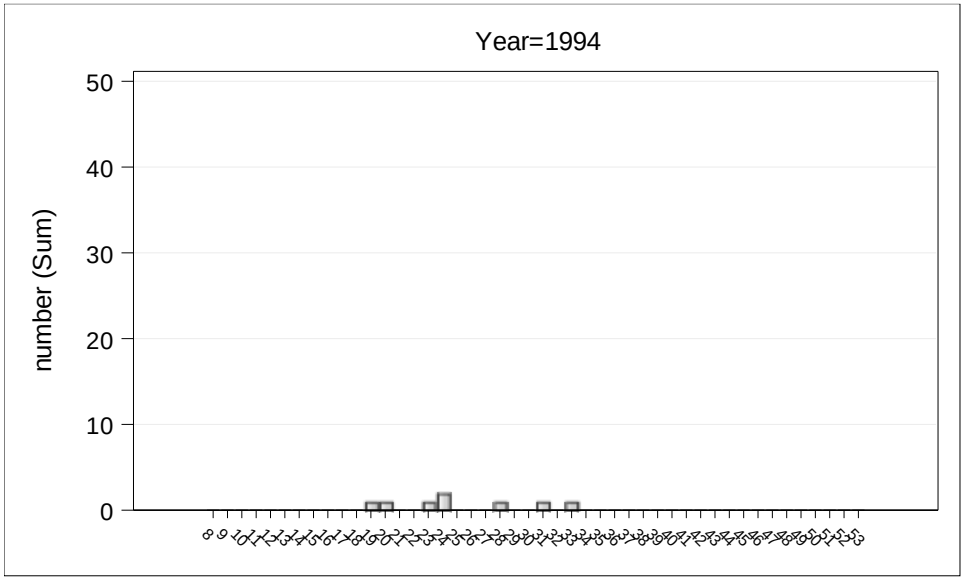
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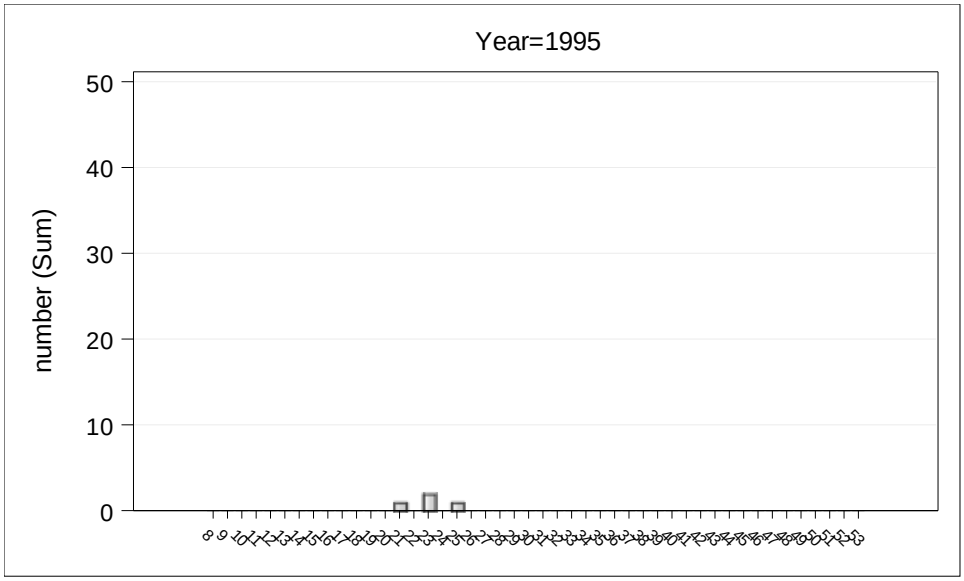
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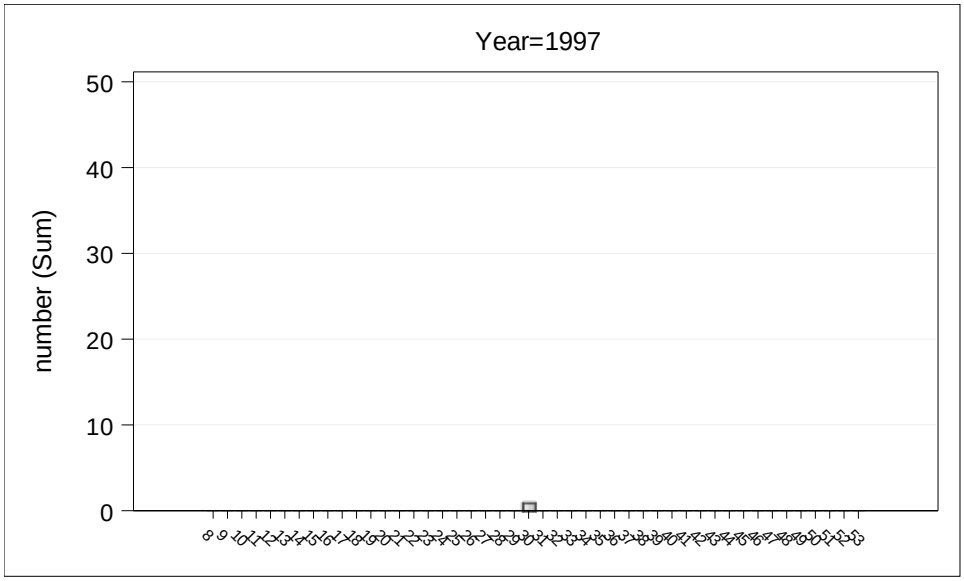
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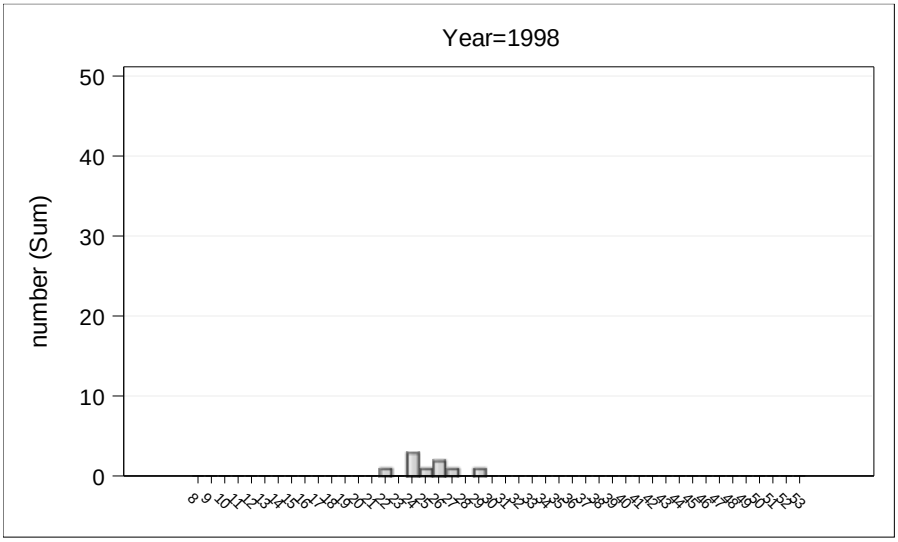
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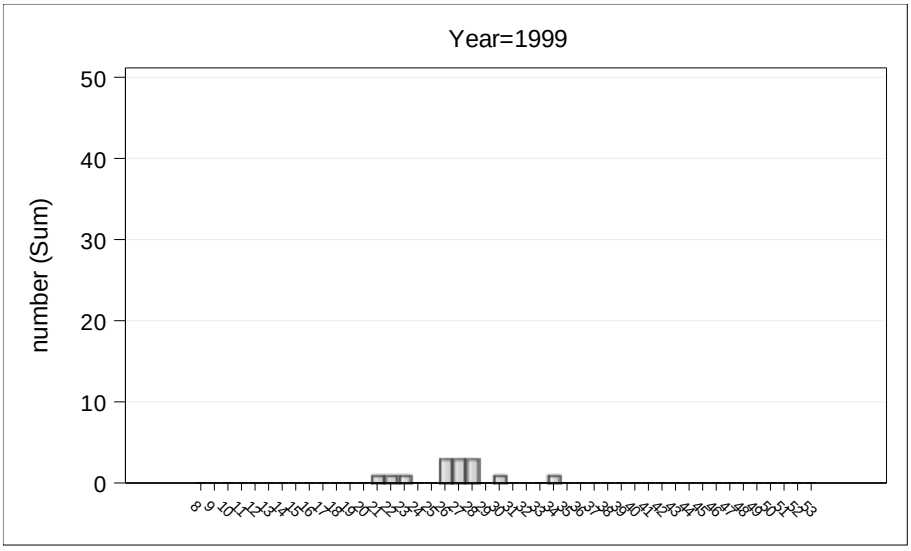
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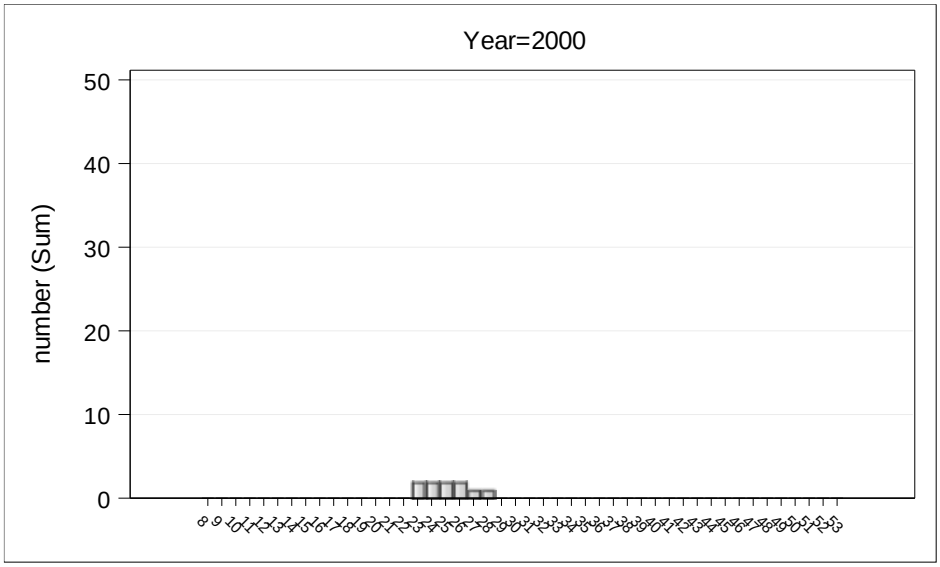
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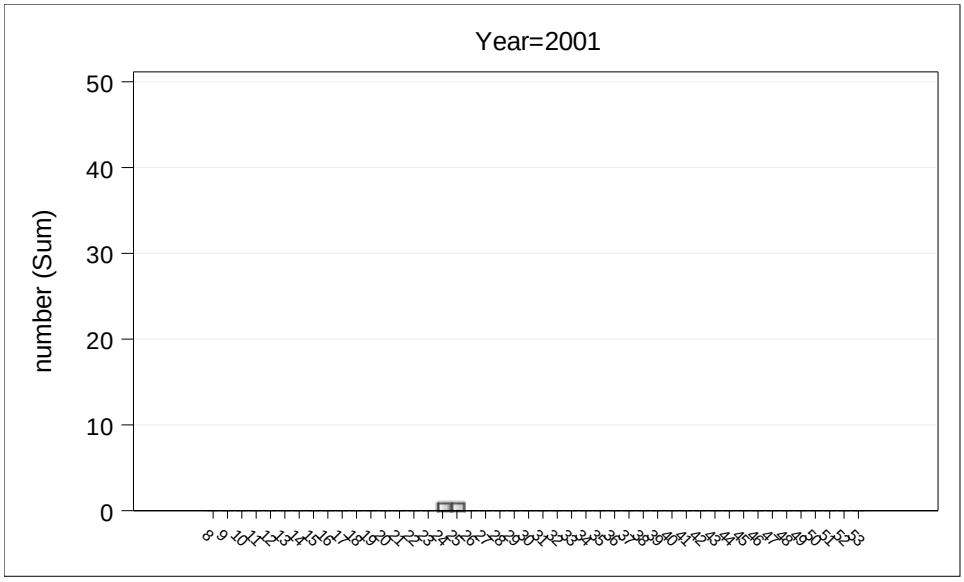
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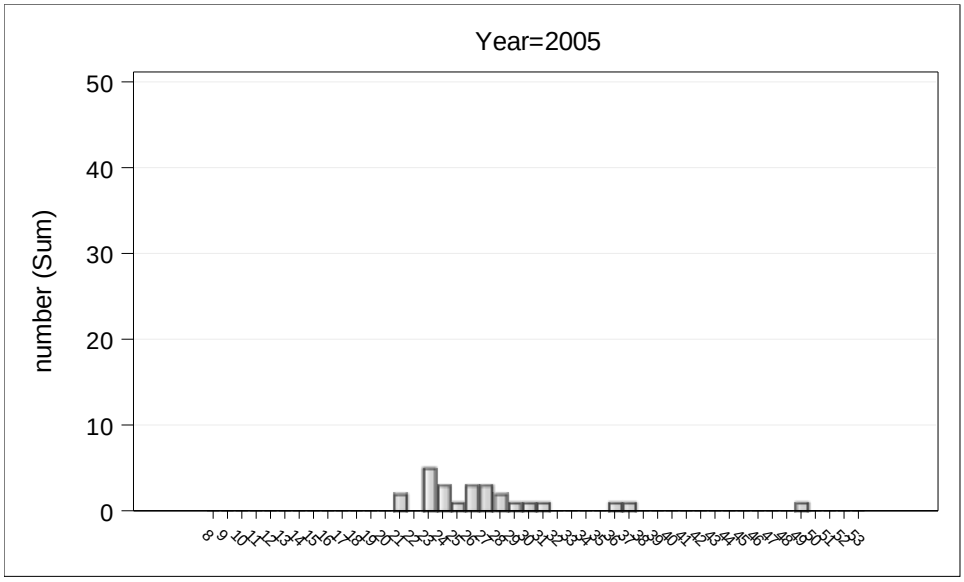
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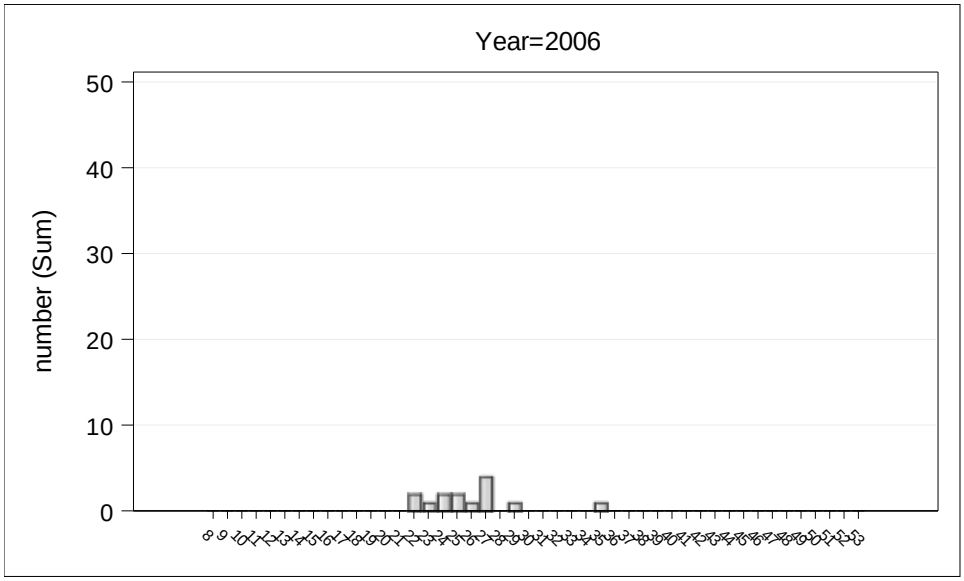
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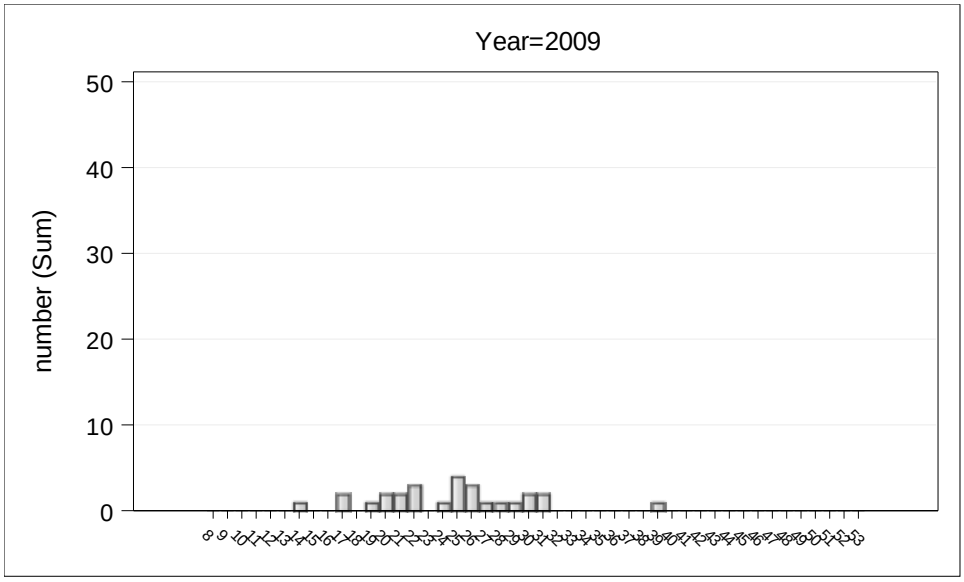
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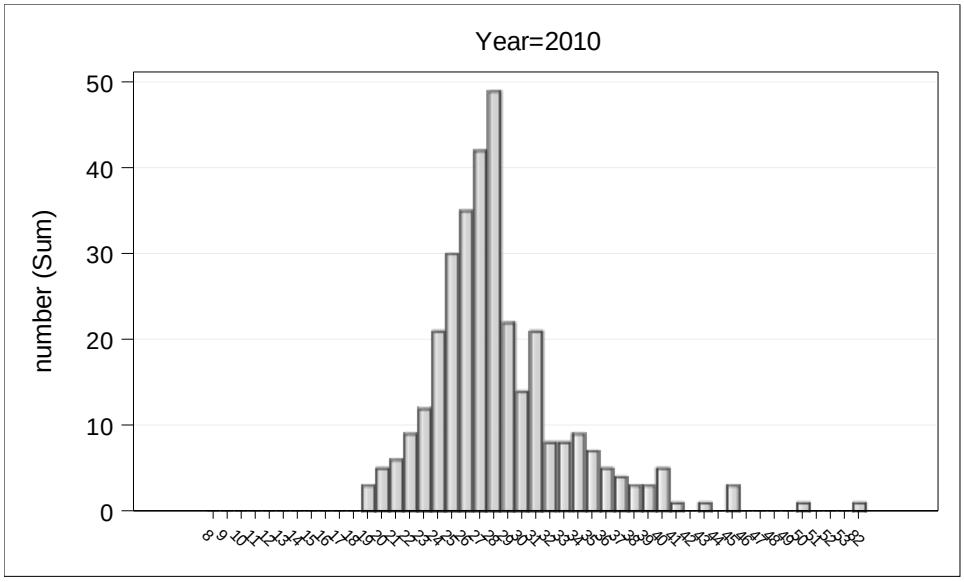
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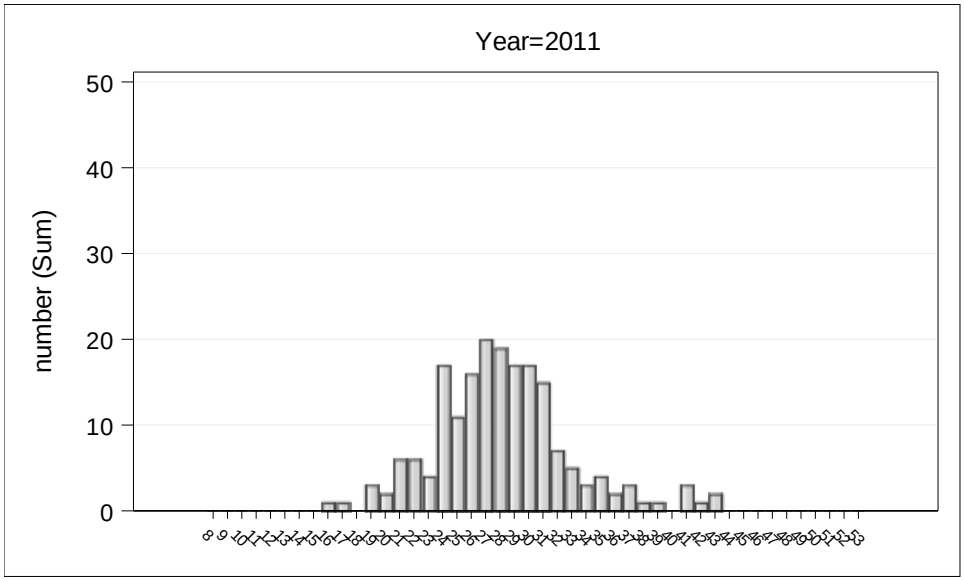
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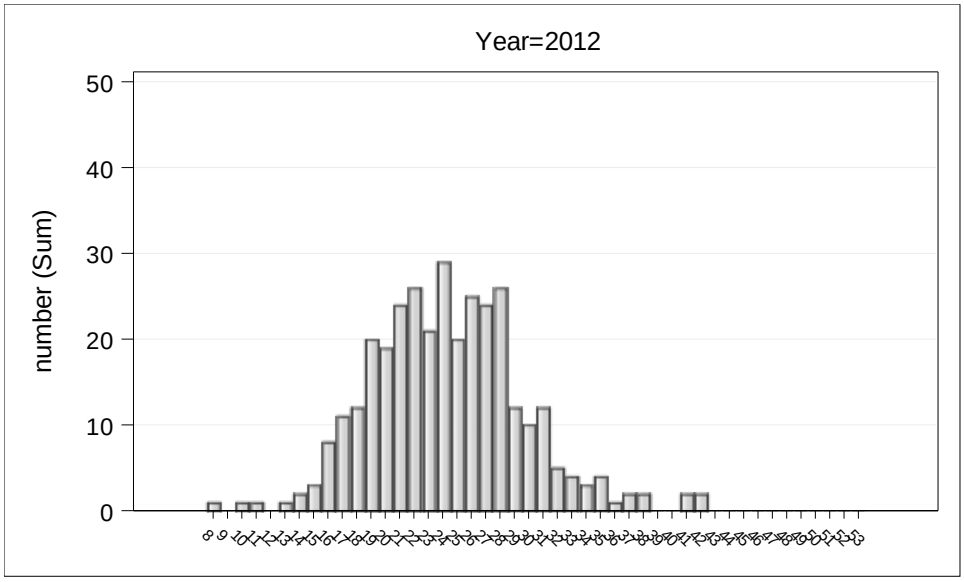
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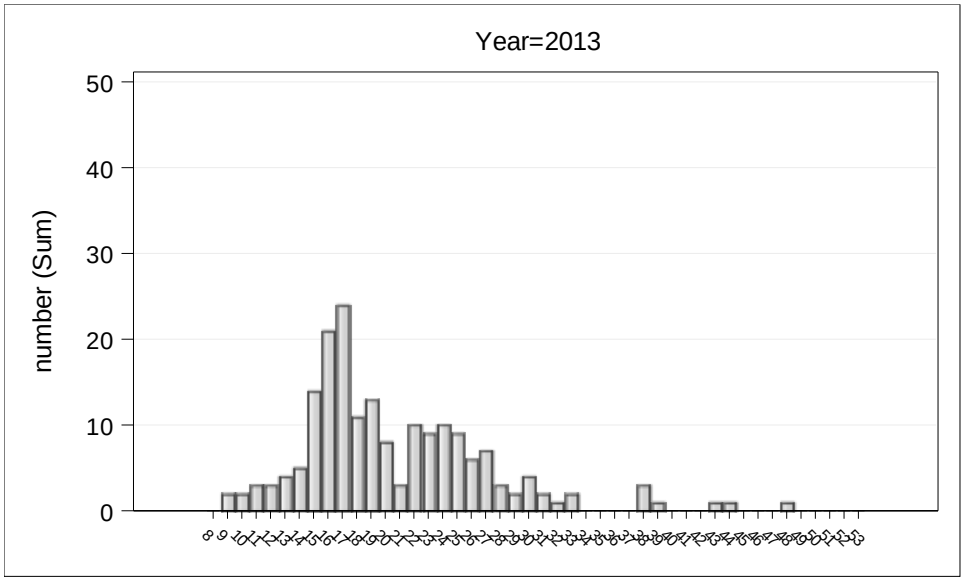
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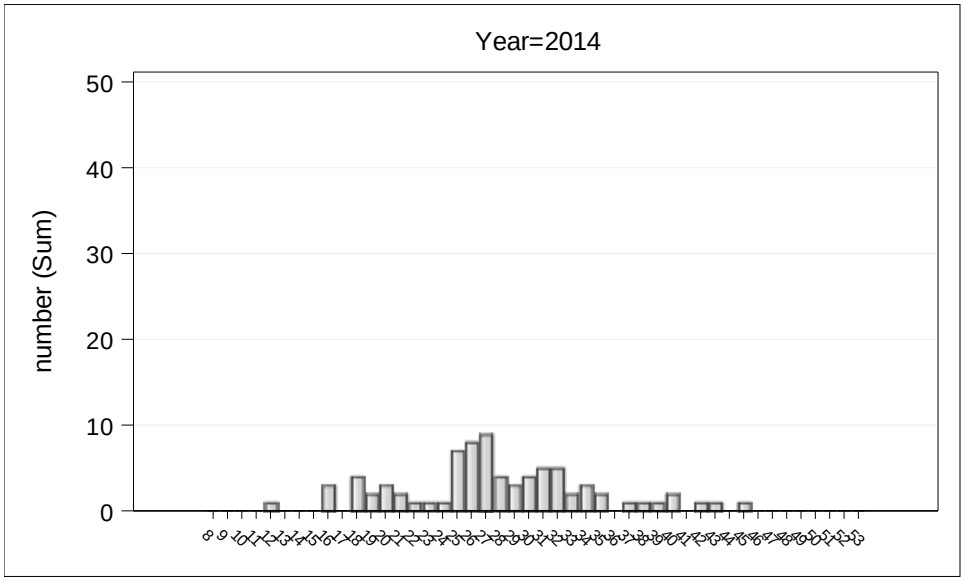
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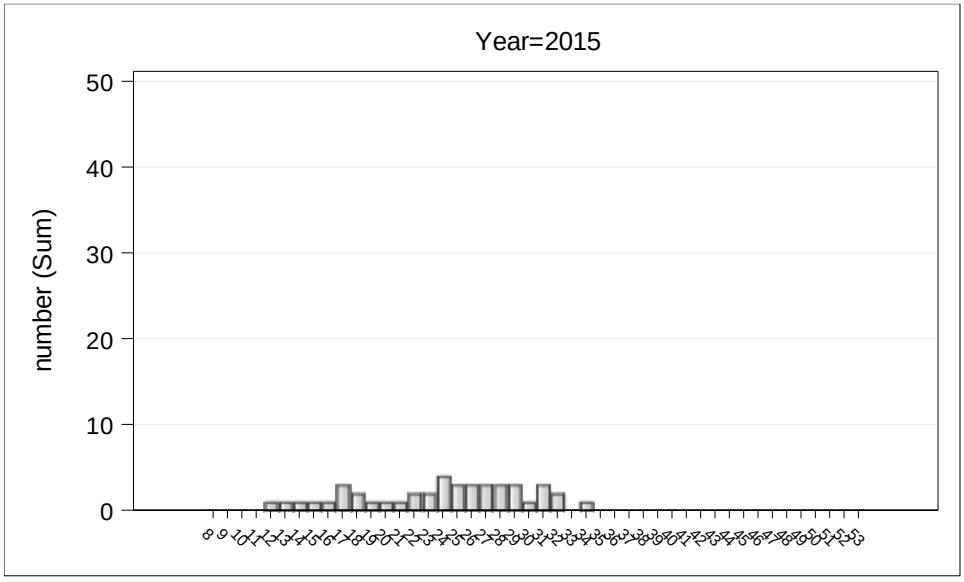
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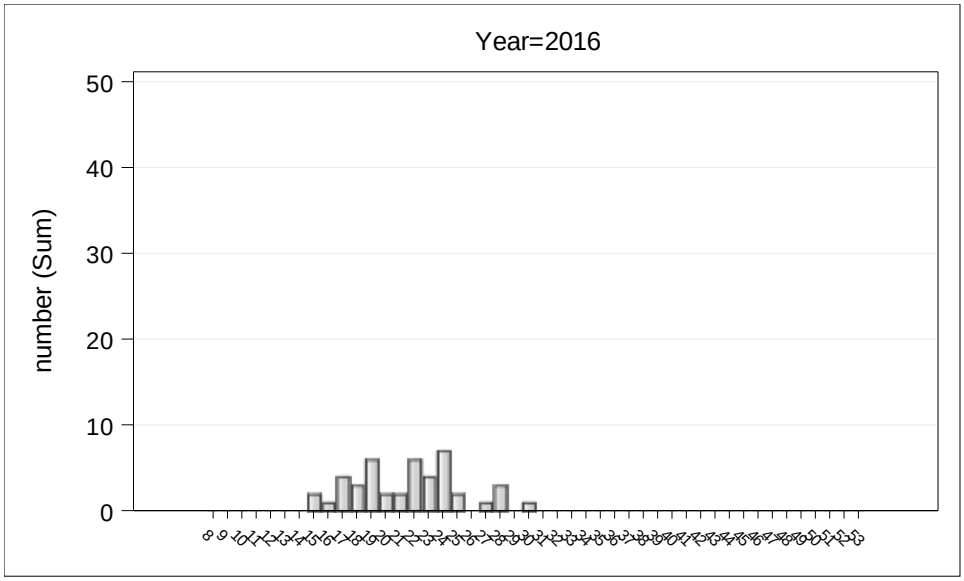
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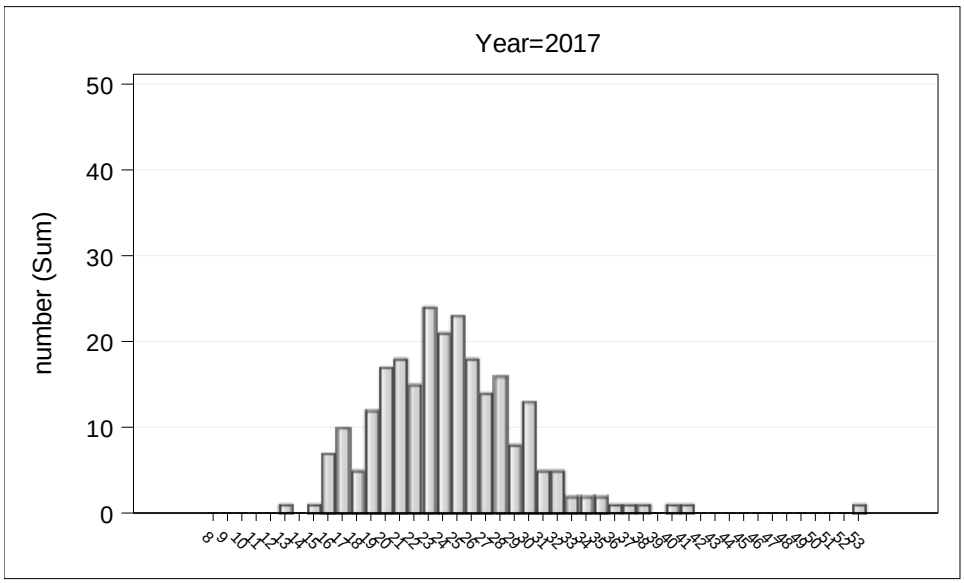
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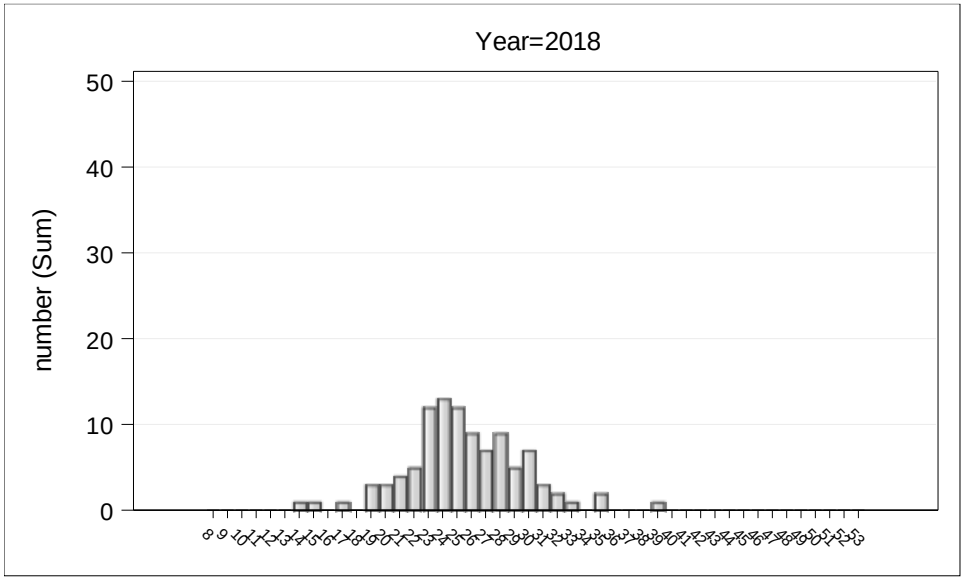
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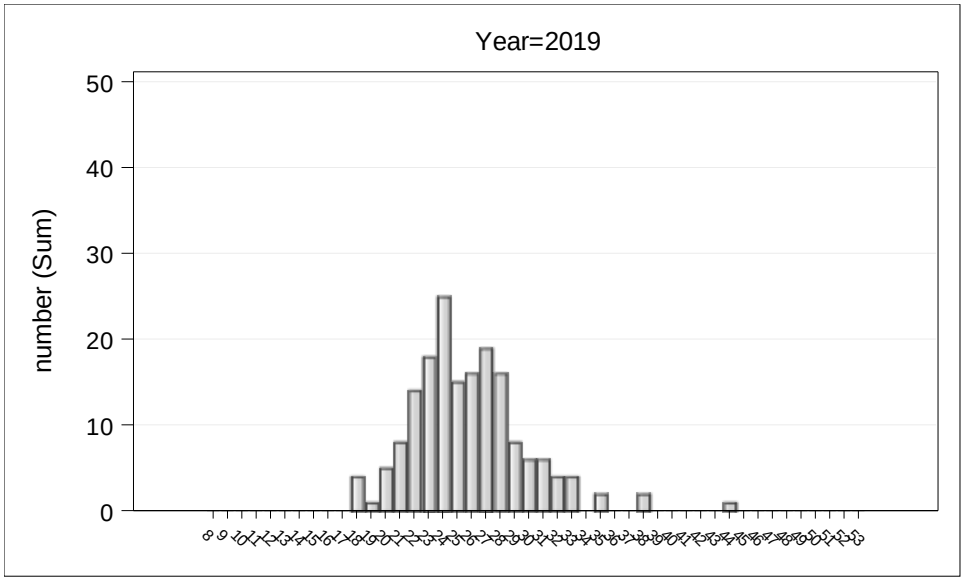
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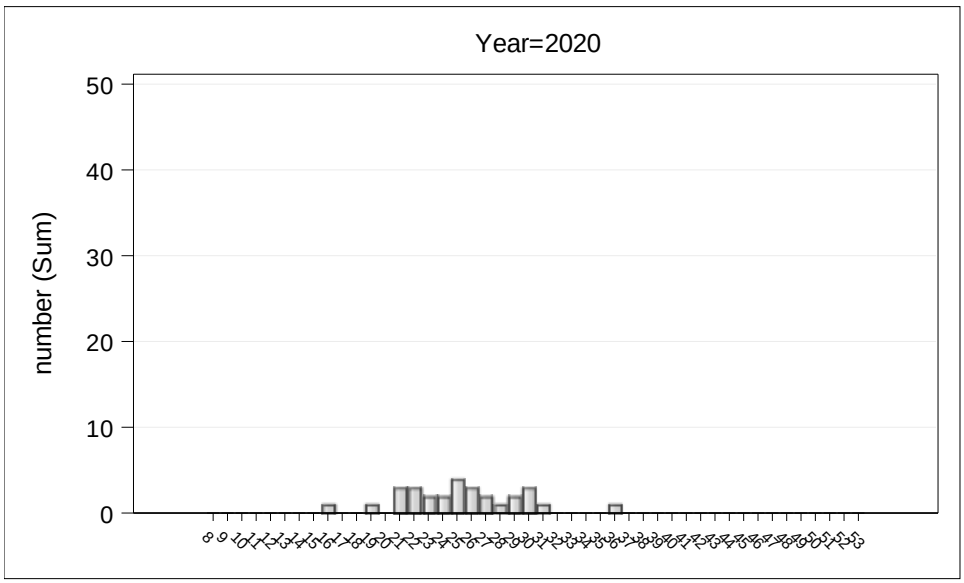
Year=2020
number (Sum)
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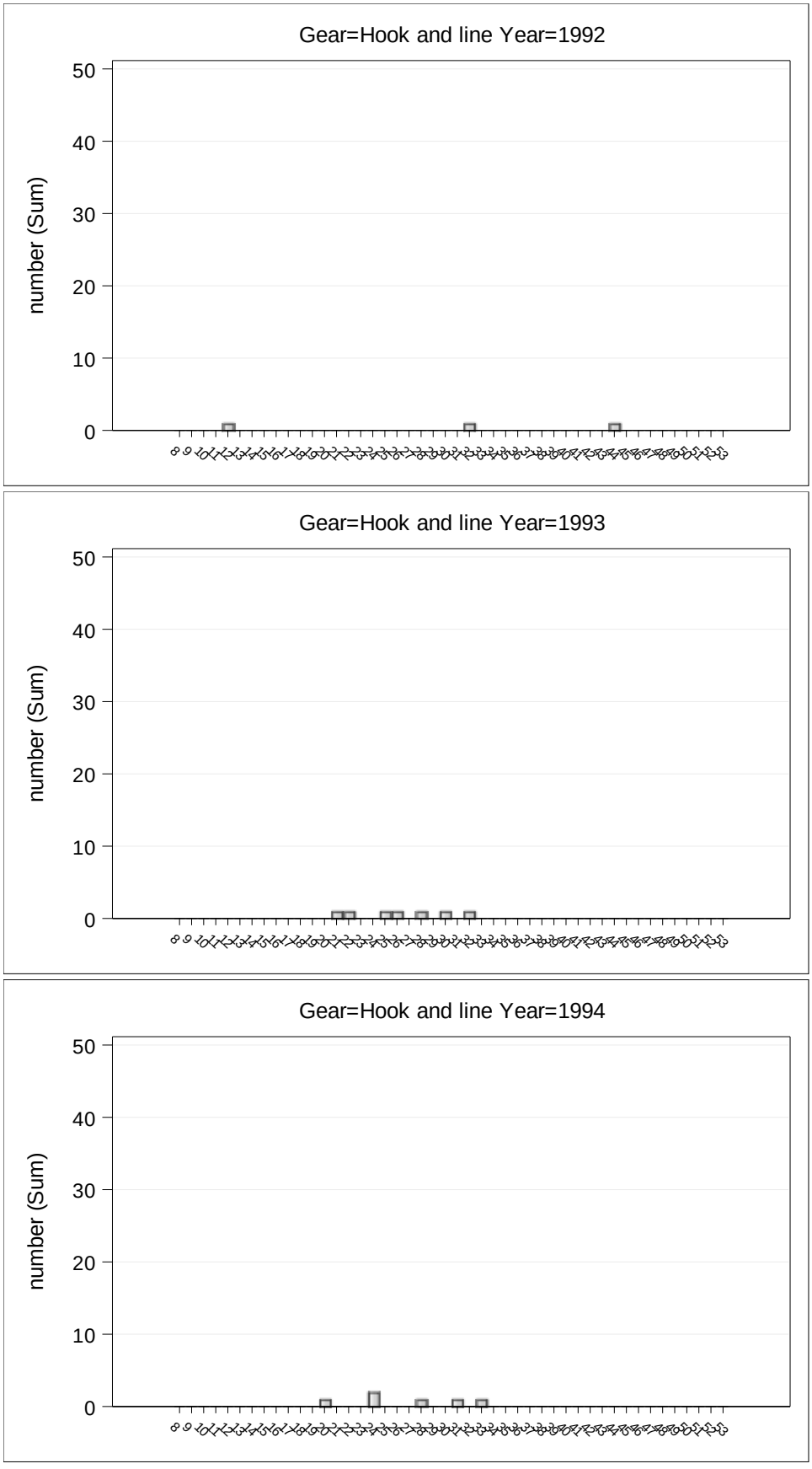
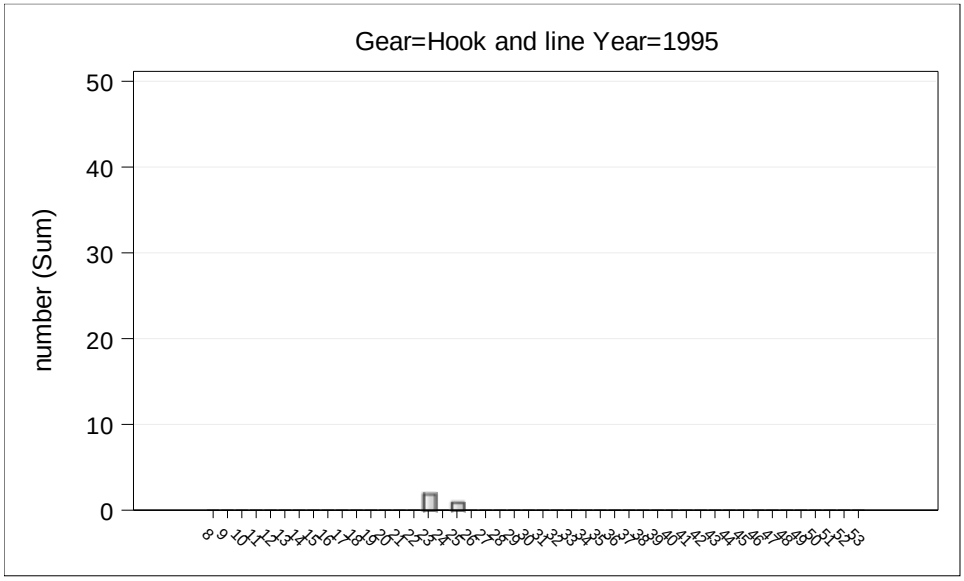
By Gear and Year

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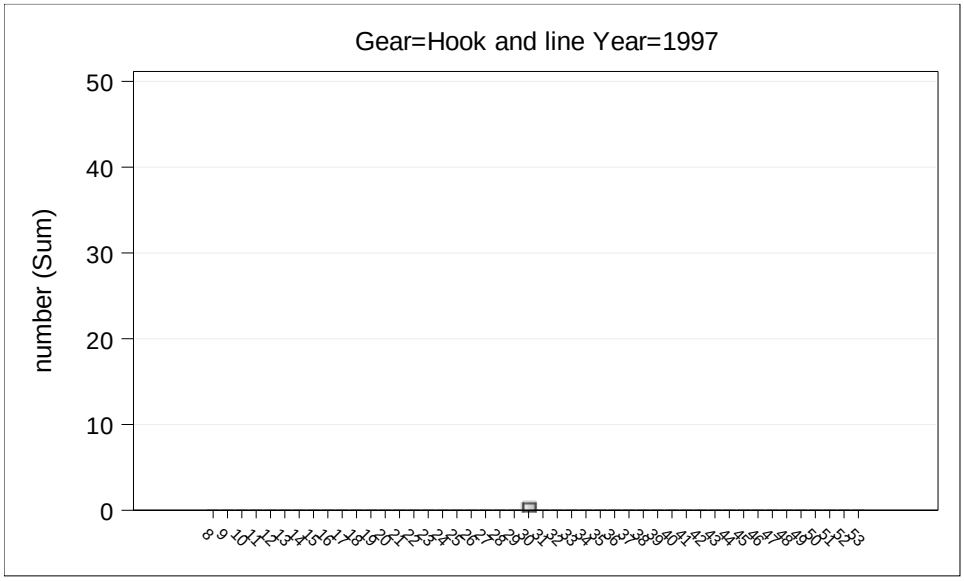
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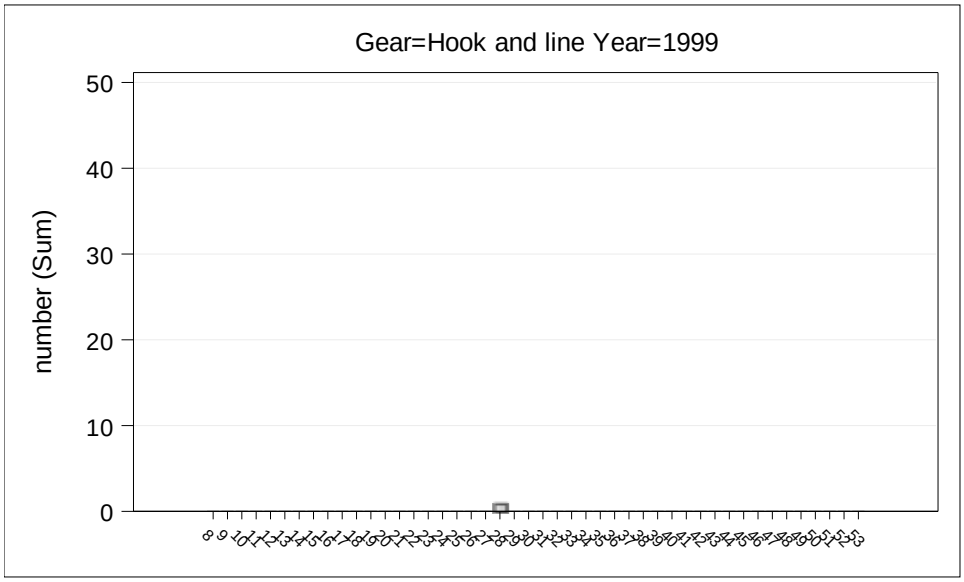
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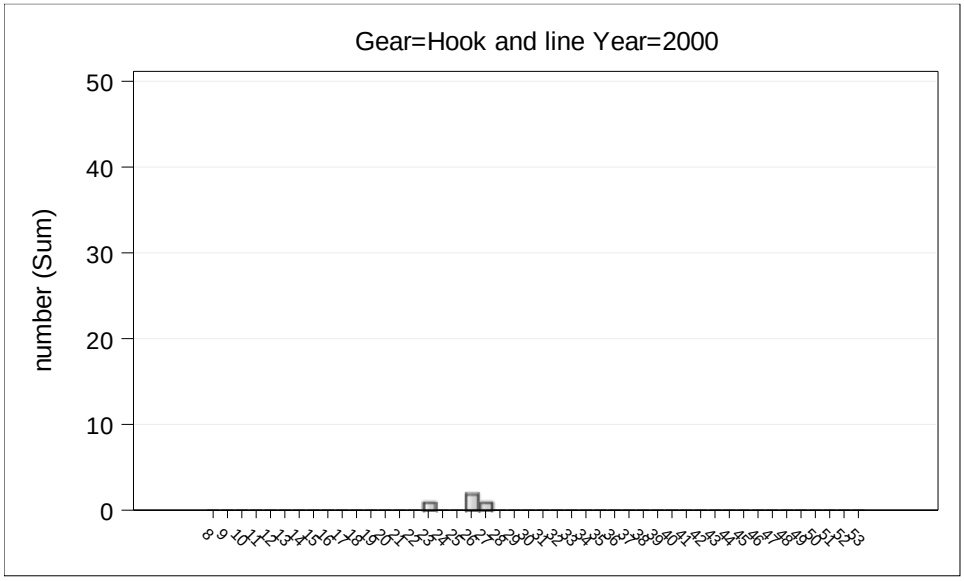
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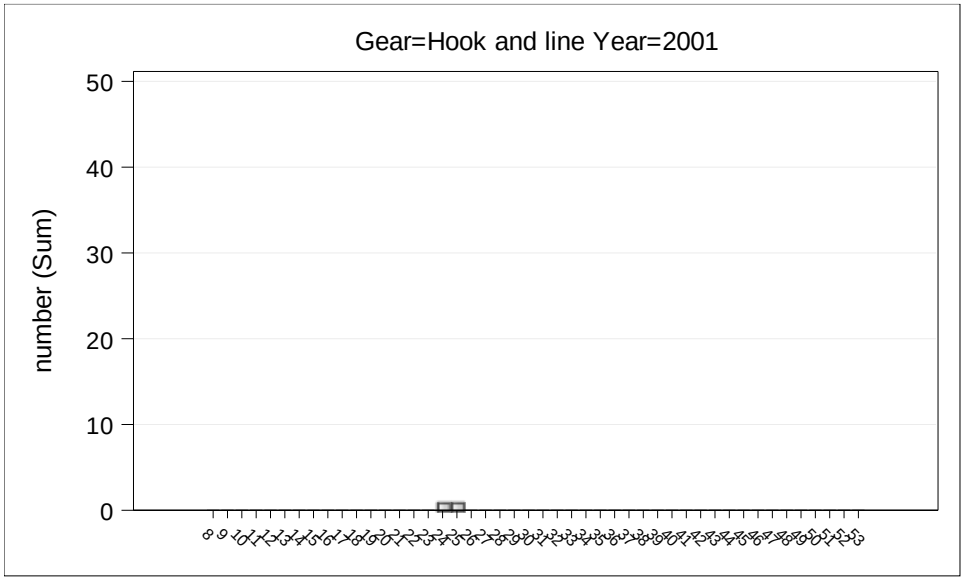
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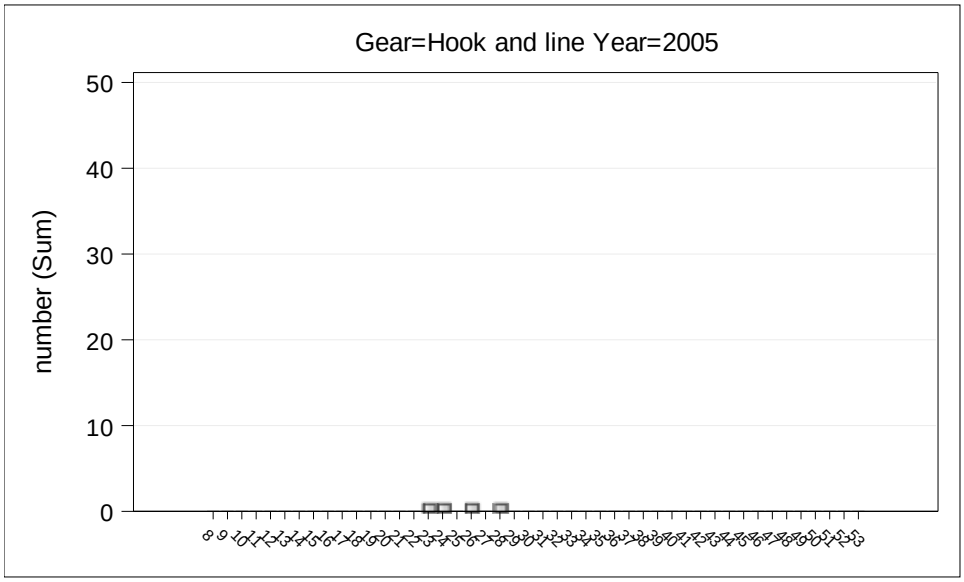
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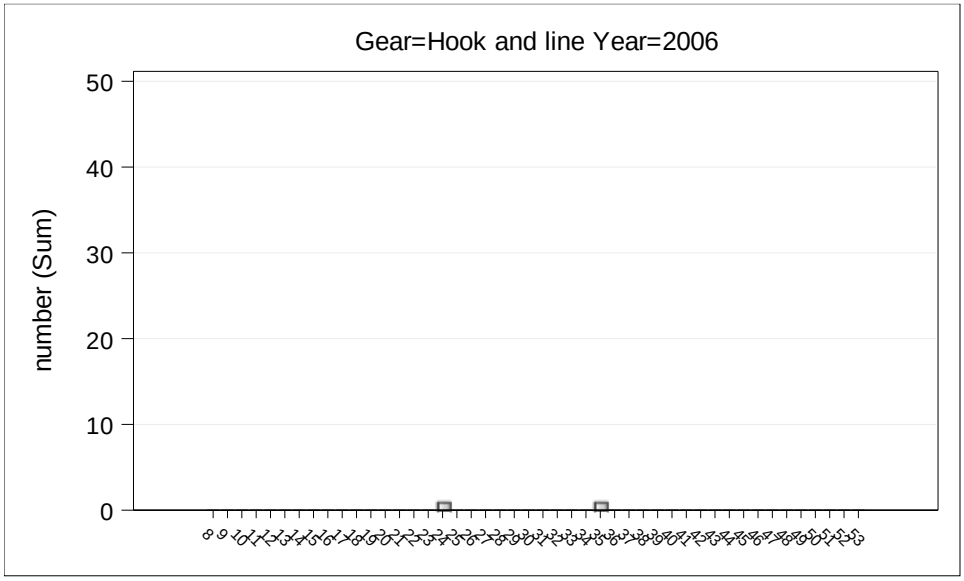
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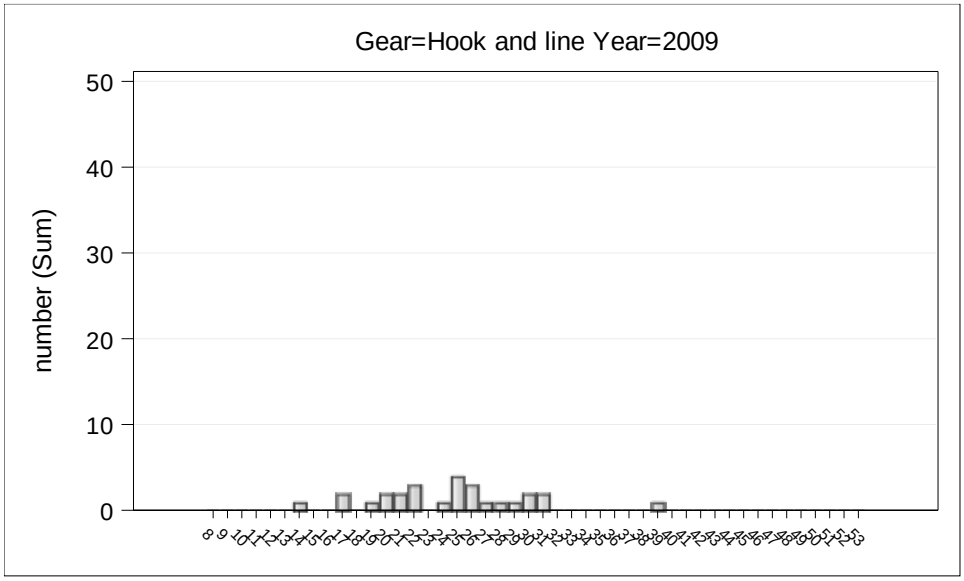
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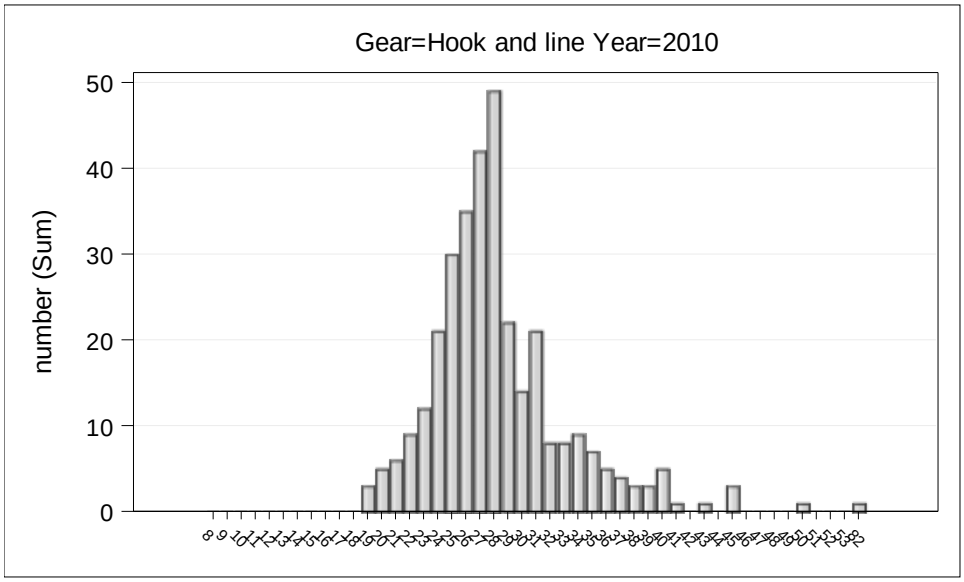
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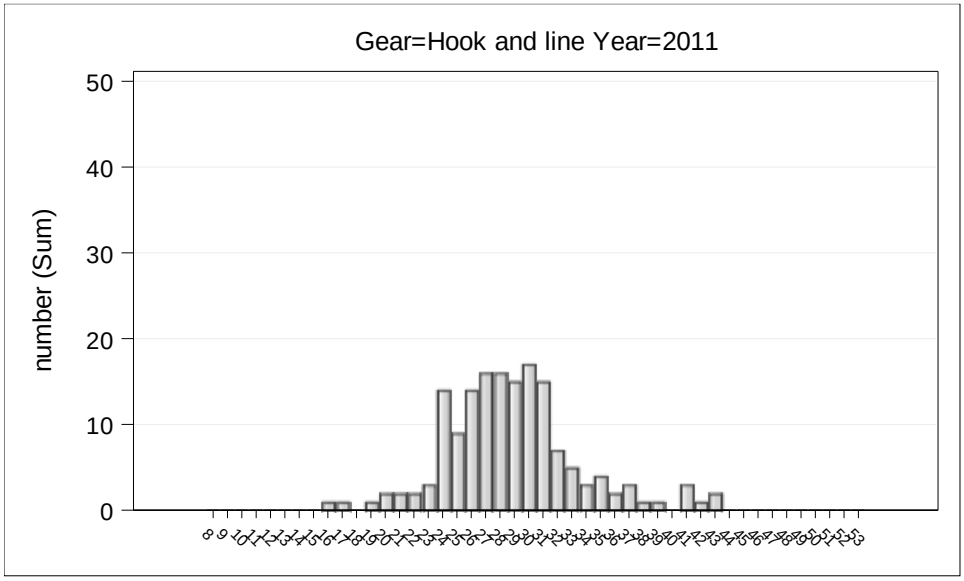
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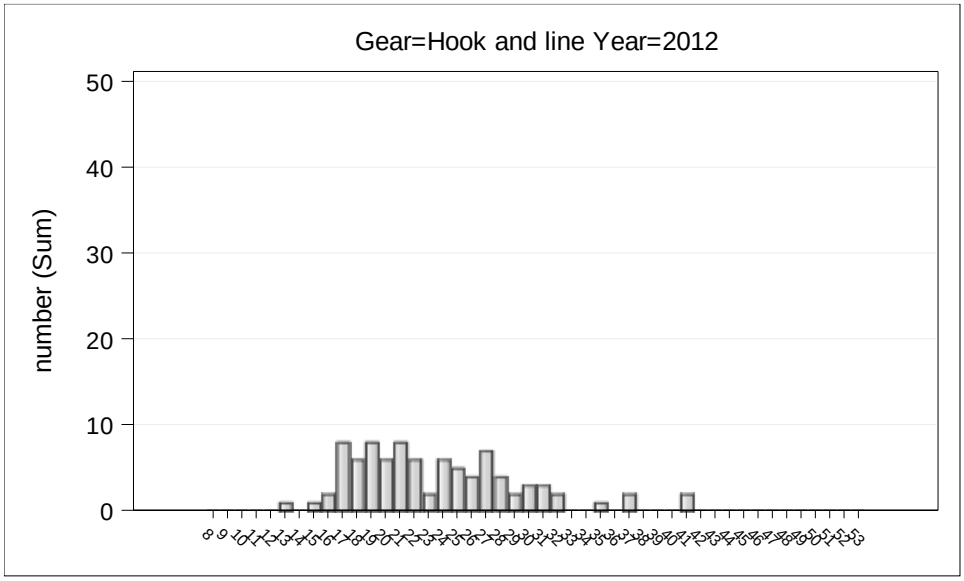
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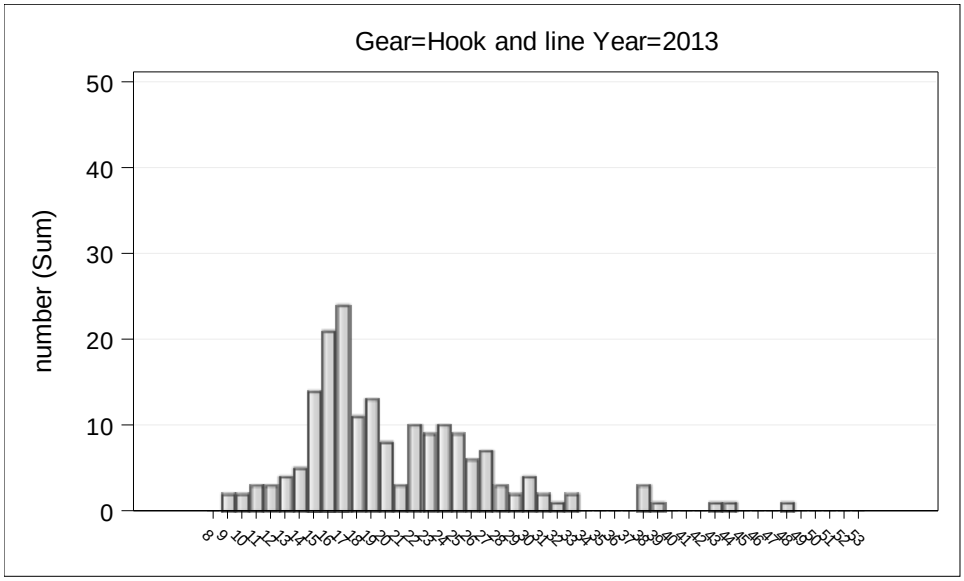
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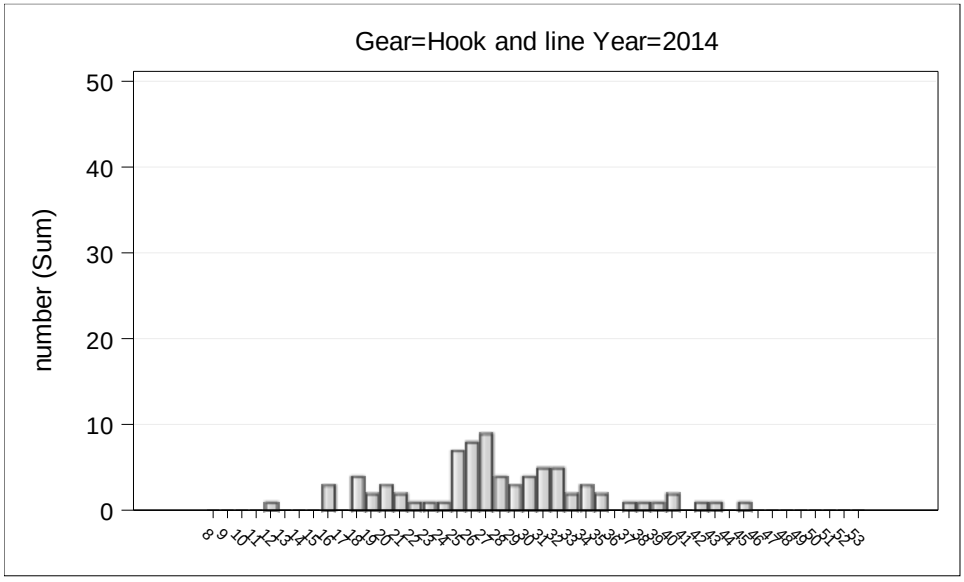
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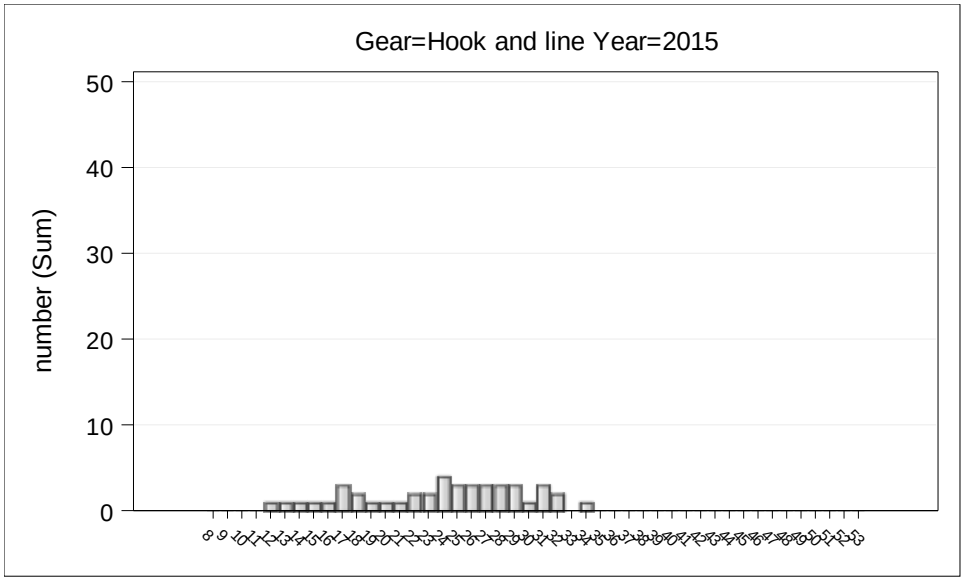
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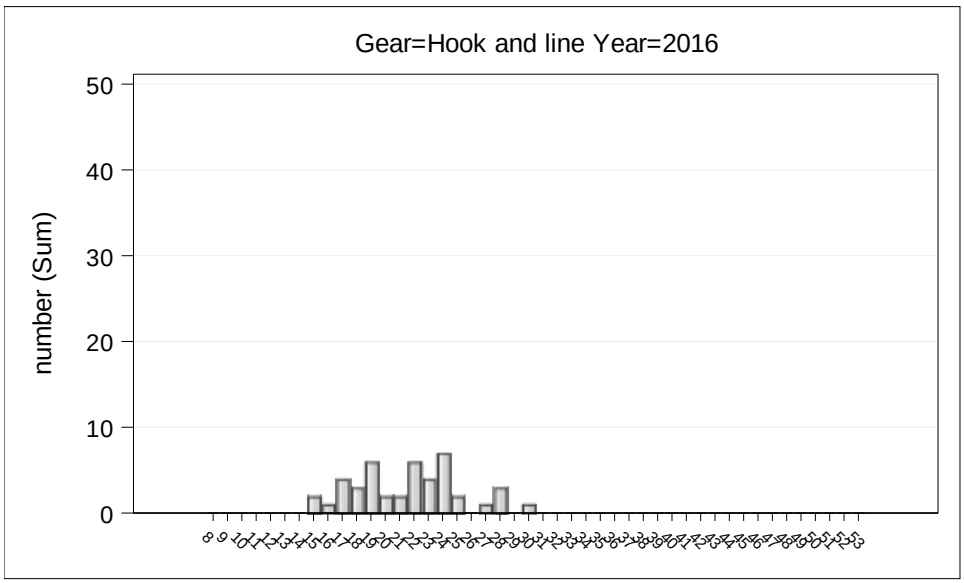
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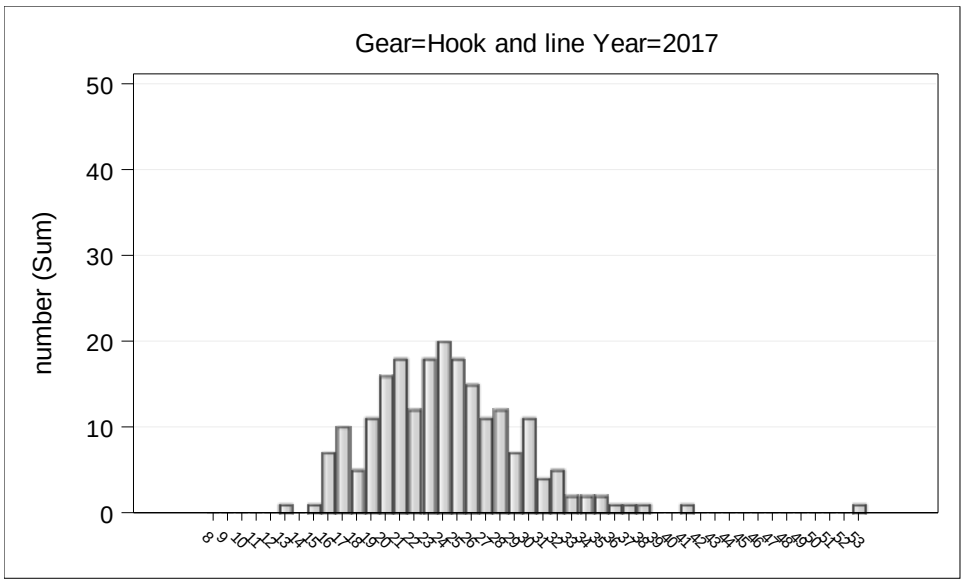
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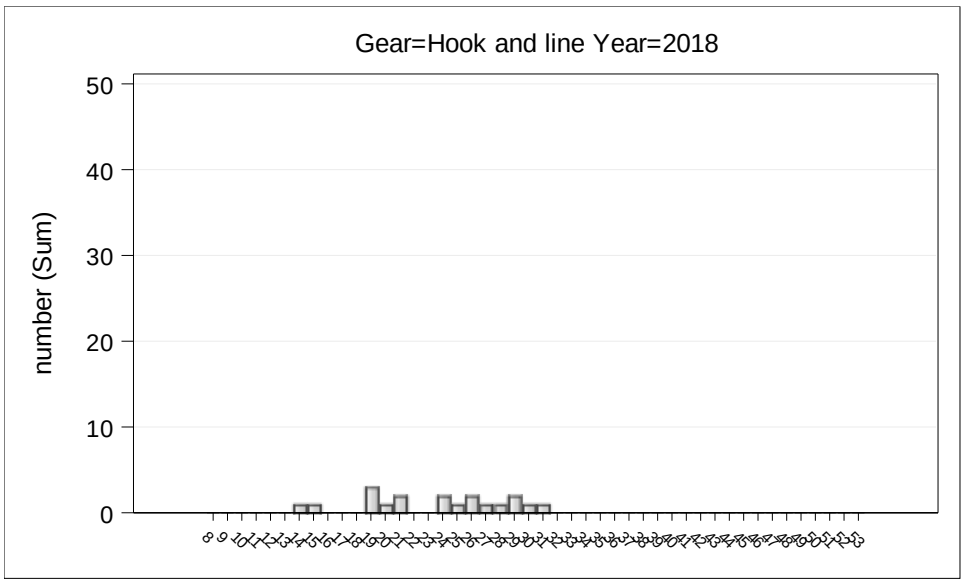
Gear=Hook and line Year=2018
number (Sum)
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10
20
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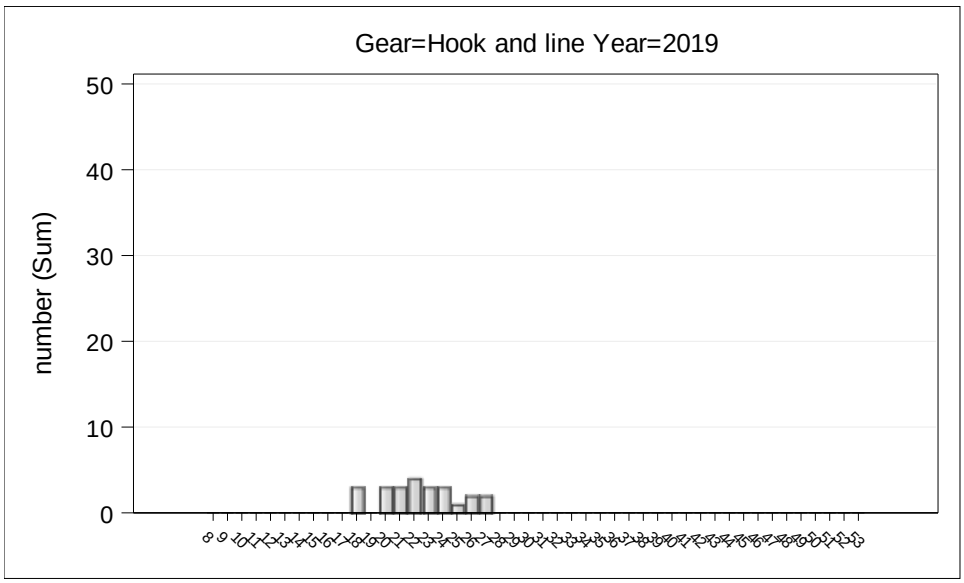
Gear=Hook and line Year=2019
number (Sum)
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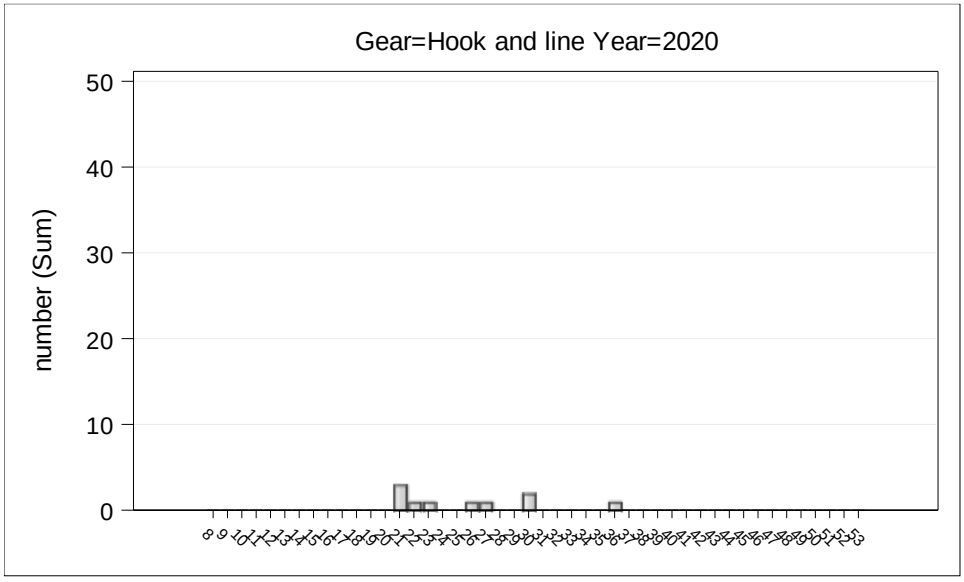
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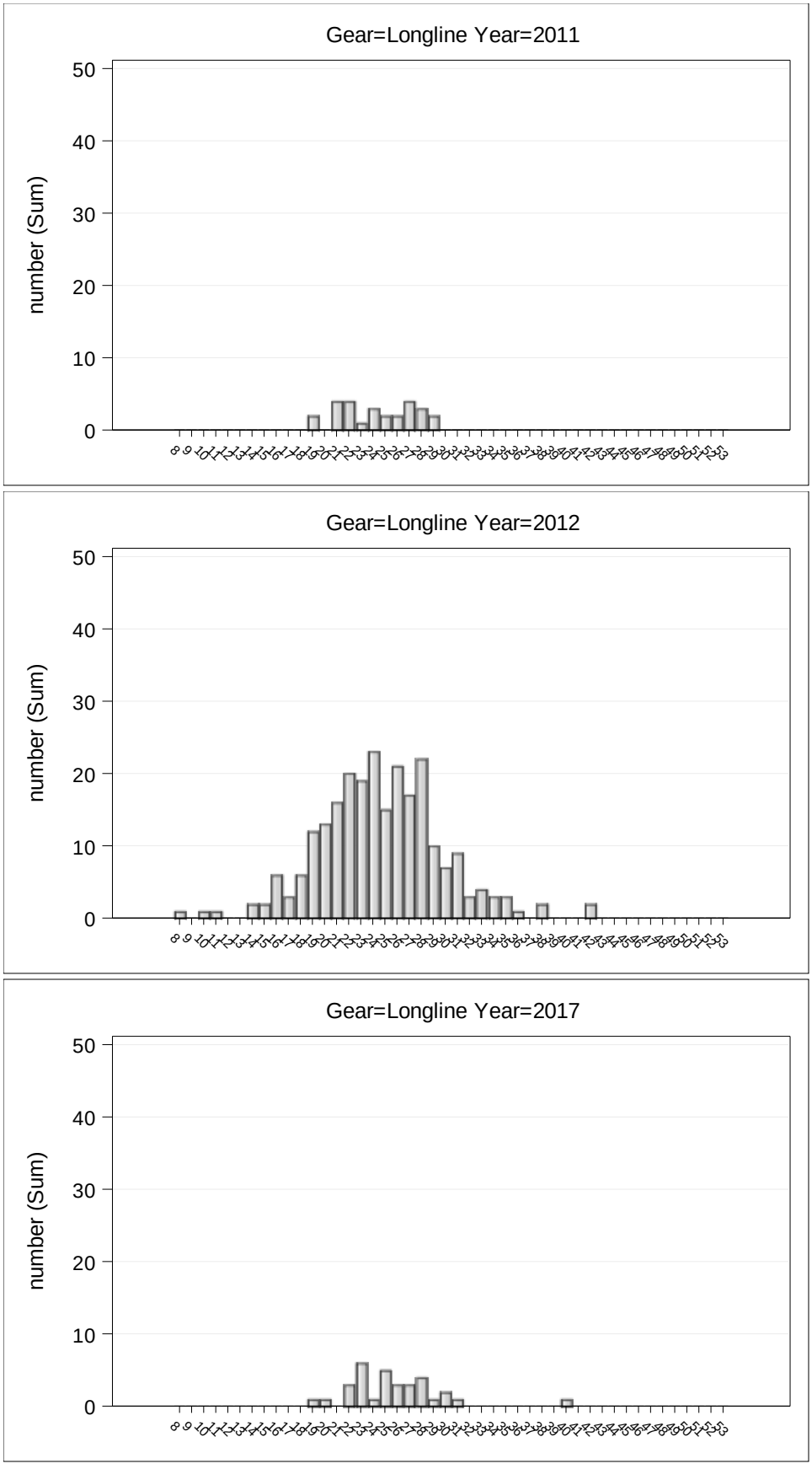
Gear=Longline Year=2011
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number (Sum)
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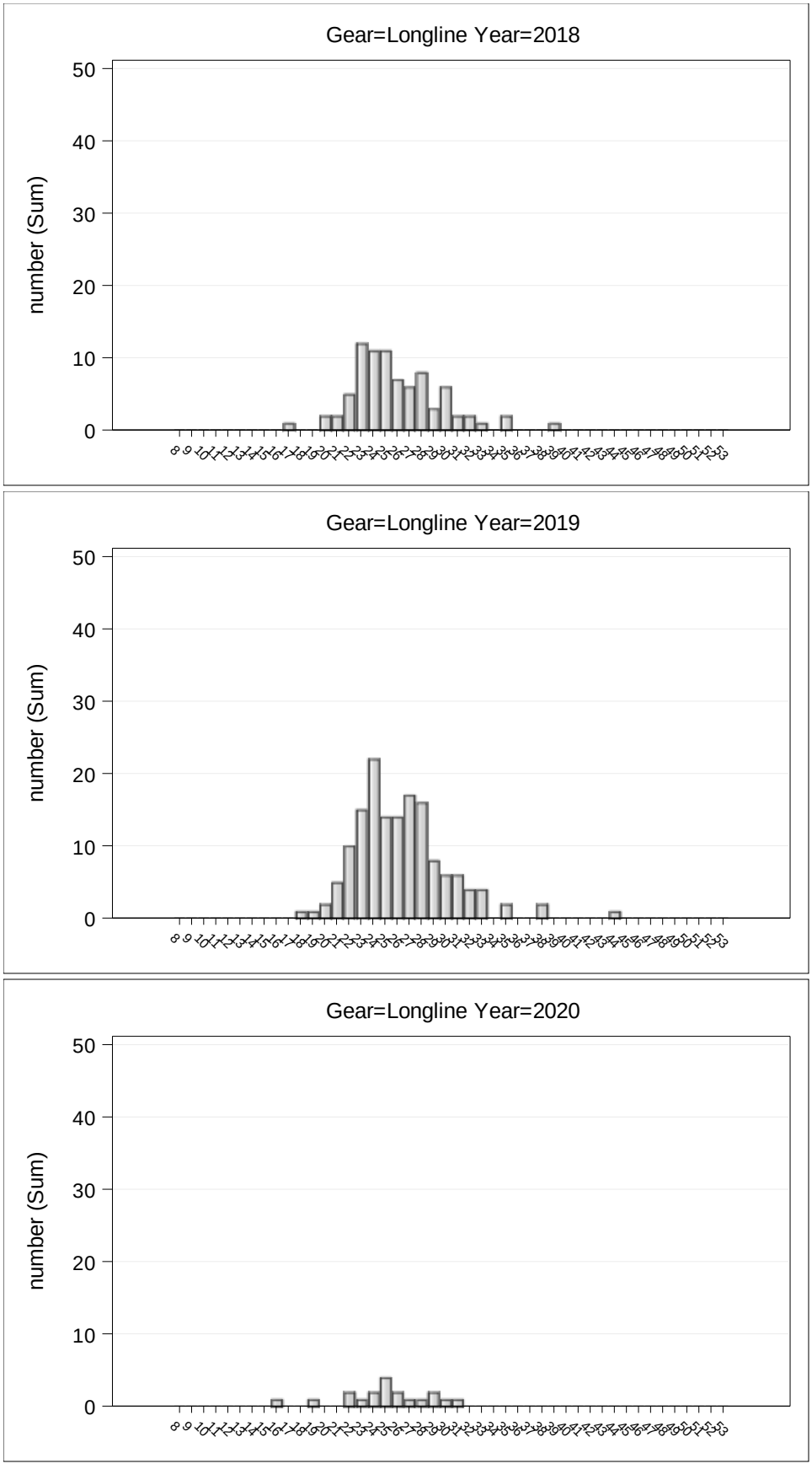
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Gear=Longline Year=2019
number (Sum)
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Gear=Longline Year=2020
number (Sum)
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20
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40
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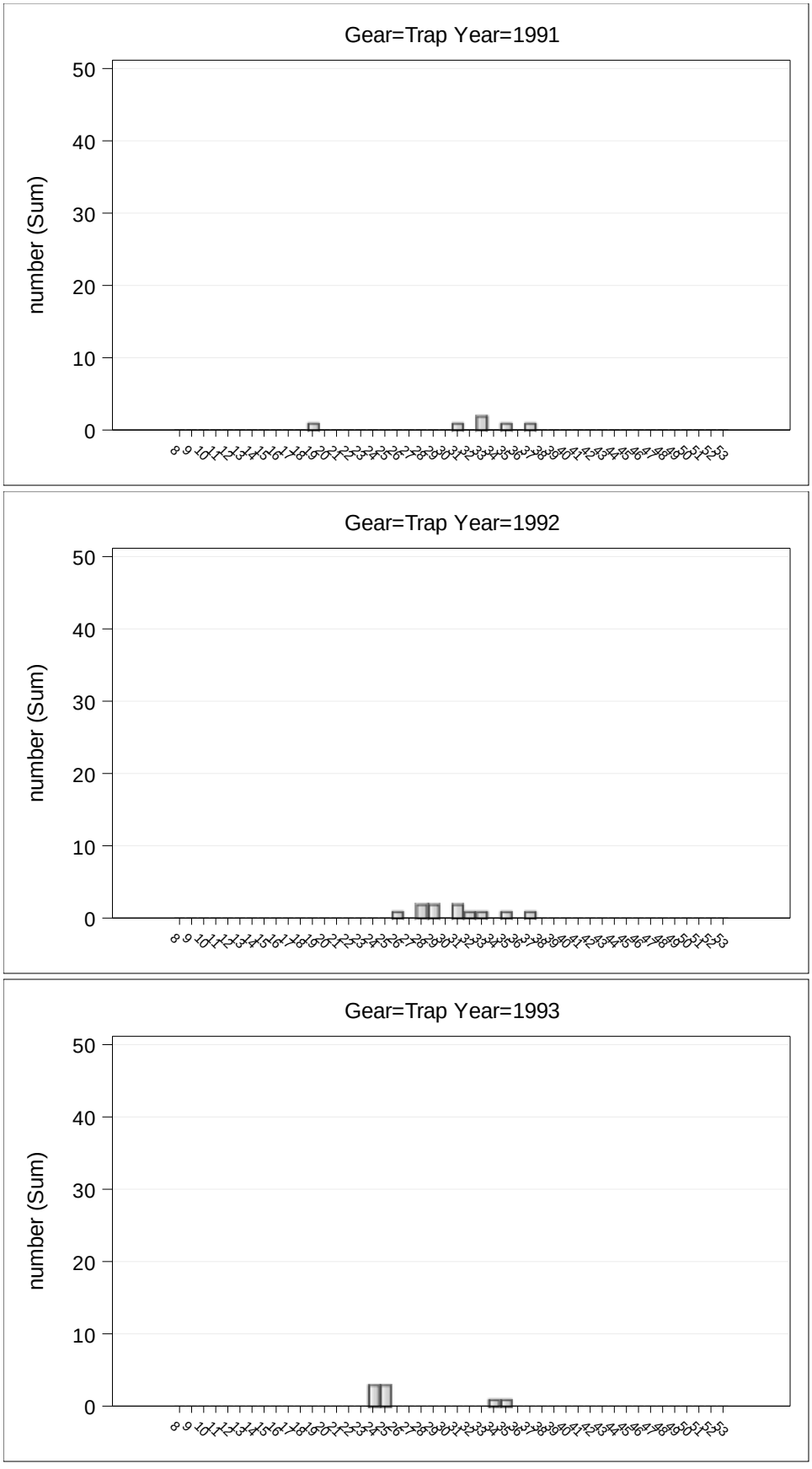
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Gear=Trap Year=1992
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Gear=Trap Year=1993
number (Sum)
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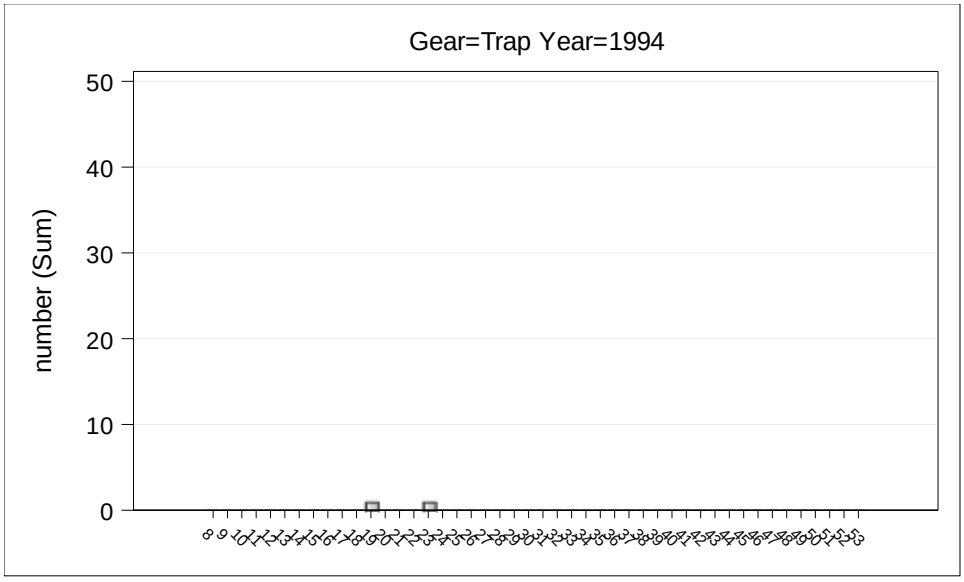
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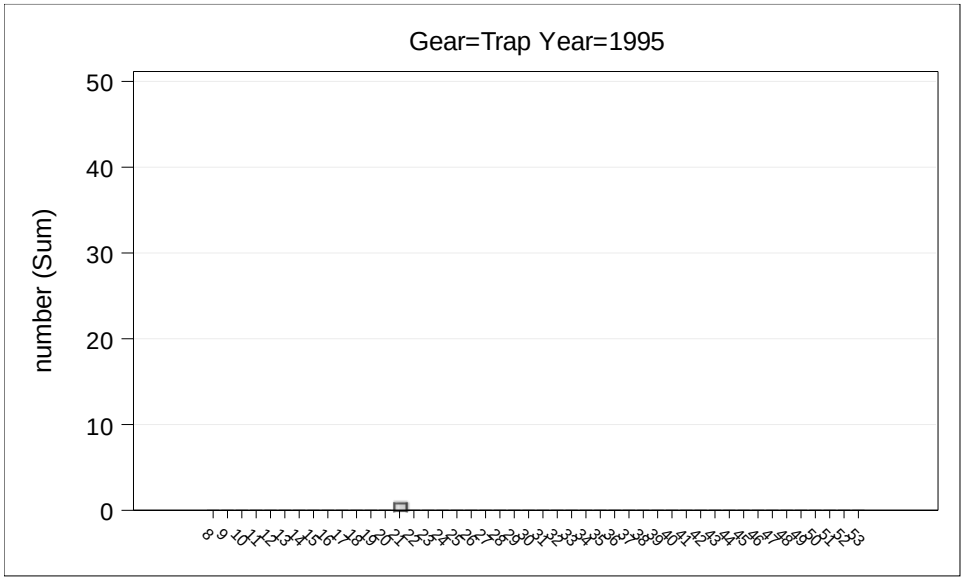
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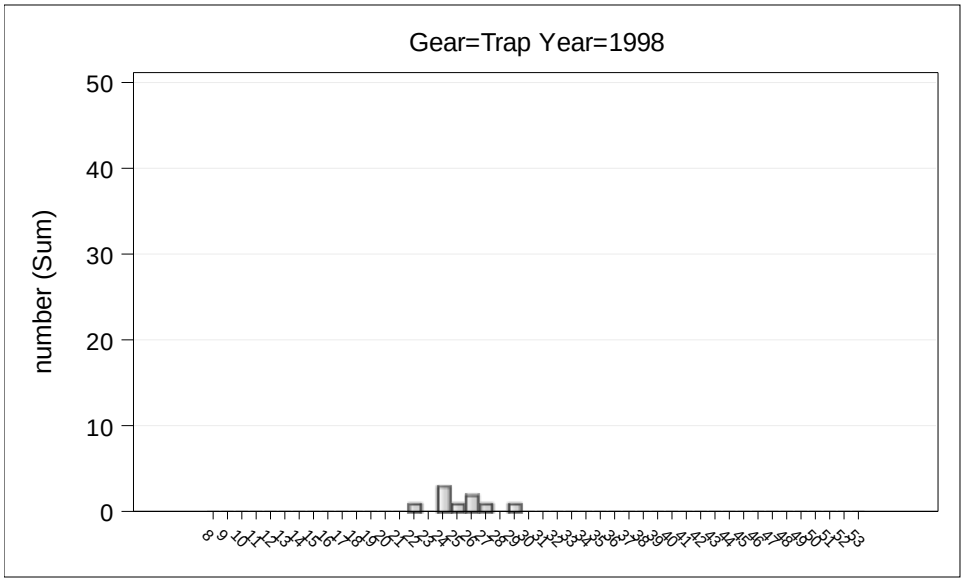
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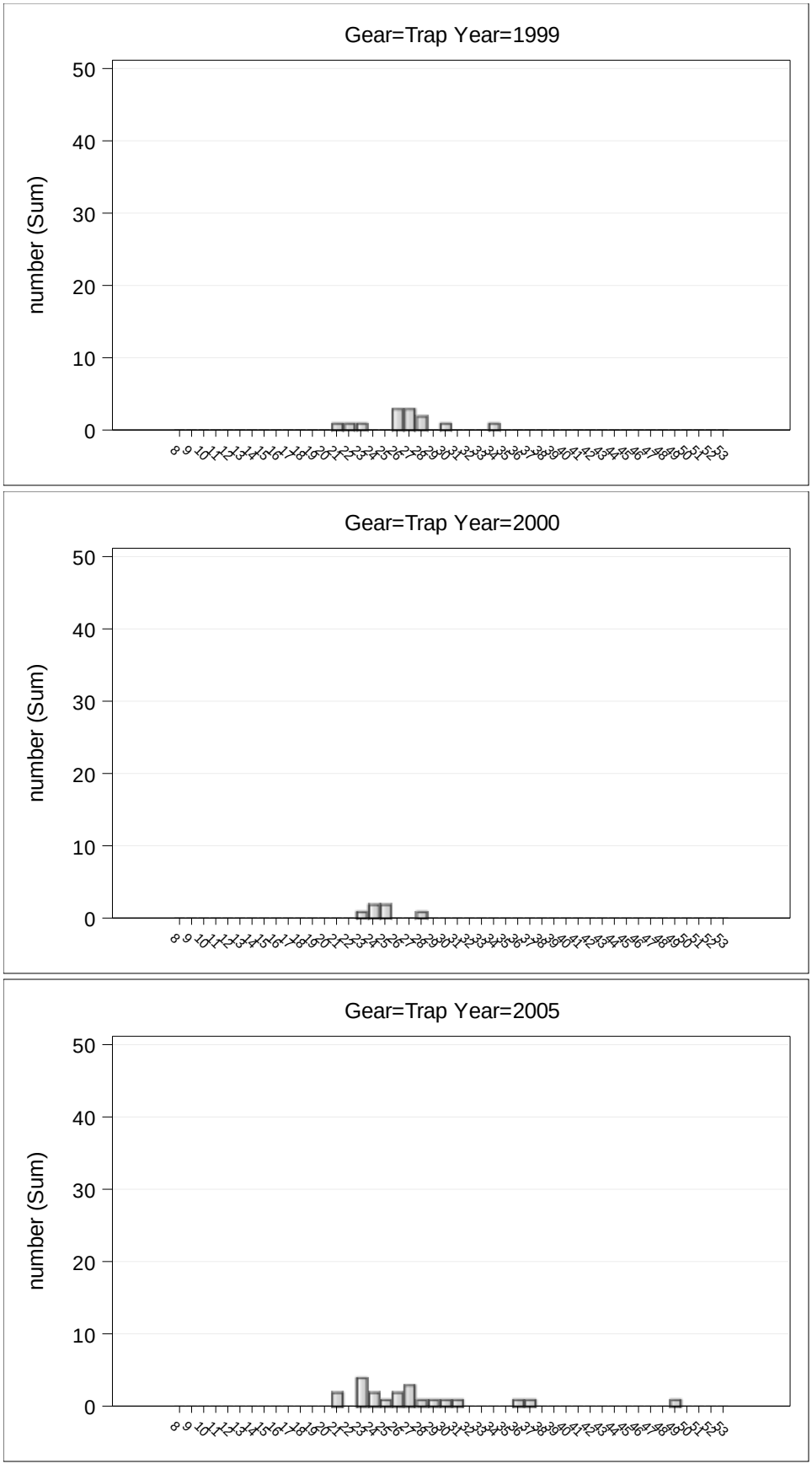
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Gear=Trap Year=2000
number (Sum)
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Gear=Trap Year=2005
number (Sum)
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40
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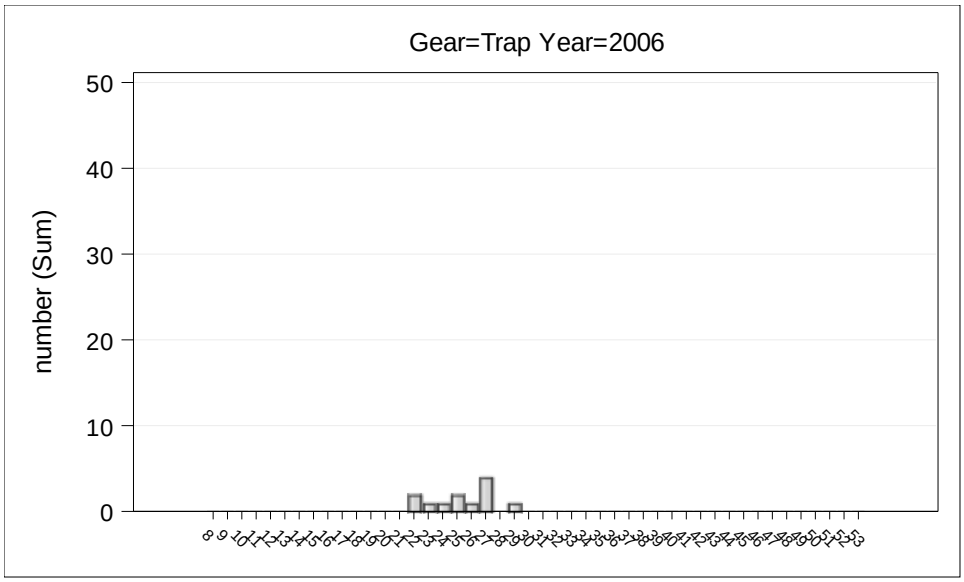
Gear=Trap Year=2006
number (Sum)
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