Preliminary Analysis and Standardized Catch Per Unit Effort Indices for Yellowtail Snapper Fishery Independent Data in Puerto Rico

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March 2005

Caribbean Southeast Data Assessment Review Workshop Report
SEDAR-AW-02
Sustainable Fisheries Division Contribution No. SFD-2005-XXX

Abstract

Data collected from fishery independent sampling efforts is used to calculate nominal and standardized catch per unit effort indices for yellowtail snapper using the Lo approach. Despite small sample sizes, catch rates for yellowtail captured using traps are found to be significant for year and season.

Introduction

Several ongoing fishery independent sampling programs are conducted in the United States Caribbean. One such program is carried out by the Department of Natural and Environmental Resources (DNER) in Puerto Rico and has been sampling reef fish off the west coast of Puerto Rico since 1988. Sampling specifically takes place from Rincon to Cabo Rojo and appears to be distributed in areas where spawning aggregations of grouper are found. A predefined grid was established consisting of 2 x 2 mile cells called quadrants, within which sub-quadrants (0.5 x 0.5 miles) are defined. The sub-quadrant (0.5 x 0.5 miles) is used as the sampling unit and referred to as a "station," each of which is located by GPS and stratified by depth (Figure 1). When a vessel samples a station, survey design calls for 12 fish traps to be set with three traps set per string (4 sets) (Figure 2). Traps are located 150 feet from adjacent traps to avoid interference and soaked for five to six hours (Figure 3). While the traps soak three fishers actively fish three lines, each with three hooks for four to five hours (Figure 4 and Figure 5). Hooks are baited with squid and fish traps are baited with sardines. Fish traps were constructed of 1.25-inch hexagonal wire mesh and changed to 1.5 inches square mesh in the year 1994. Since their inception in 1988, the surveys have predominantly captured groupers (red hind and coney) with yellowtail only consisting of a limited number of individuals (Figure 6 and Figure 7). Fishing effort, catch, location and biological data were collected for each fish that was captured and this information is used in the subsequent analysis (Cummings 2005).

Methodology

Calculation of yellowtail snapper indices was completed using only those sampling days on which yellowtail were captured. The data was stratified by gear and by year. Nominal catch per unit effort (CPUE) indices were calculated for both hook and trap catch in terms of weight in grams and hours fished for those days on which yellowtail snapper were caught (positive trips). Adjustments were made for occurring fluctuations in effort. Effort for hooks was calculated in terms of the sum of the hours fished times

number of hooks for a given day (hook*hours), while effort for traps was measured as the sum of the soak time for each trap on a given day. Standardized catch rates were calculated for trap data only; hook and line data was found to be sparse with few observations and so only a nominal CPUE was estimated. The standardized index for trap data was calculated using the delta lognormal model approach (Lo, et. al. 1992). Parameterization was calculated using a generalized linear model (GLM) procedure (GENMOD; Version 8.02 of the SAS System for Windows 2000. SAS Institute Inc., Cary, NC, USA). GLM procedures were used to identify significant factors for the proportion of positive trips and catch rates on positive trips. Factors considered as possible influences on the proportion of successful trips (i.e. those that capture yellowtail) included season and year (Cass-Calay and Valle-Esquivel 2003).

Results and Discussion

Catch Rates

The data collected by the Puerto Rico DNER is representative of the multispecies fishery that exists in Puerto Rico. The disadvantage of this is the fact that for some species, sample size is larger than others, with catch being contingent on a variety of environmental and biological factors. For yellowtail snapper, sample size is comparatively small. Attempts were made to stratify the data spatially and temporally in order to determine possible reasons for the small sample size and, more importantly, to determine an appropriate means of conducting analysis. Over the sample period (1988 to 2001), effort was highest in the spring season (Figure 8) and appeared to be greatest in the months of May and September (Figure 9). Annually, effort was variable, but greater for traps as compared with hook and line. The relationship between the number of different stations sampled and effort shows that one is not always dependent on the other (Figures 10 – l3).

Nominal yellowtail snapper hook and line CPUE appears to have increased in the early 1990's and appears to be remaining stable with the exception of a few extreme years (1882 and 1998) possibly explainable due to the fact that observations are so small (45 fish) (Table 14). For traps, the proportion of positive trips sampled is very high at the beginning of the time series (1988) and then declines in the early 1990's to a low in 1994 from which it has been increasing (Figure 15). Nominal CPUE for yellowtail captured using traps is variable in the first half of the time series, when traps were 1.25 inches in size. Trap mesh size was changed to 1.5 inches in 1994, and is indicated in Figure 16 by the break. Change in mesh size may be a reason that the catch rate was low in 1994 (Figure 16).

The standardized catch rates for yellowtail captured by traps indicates a similar trend to the nominal CPUE calculated for traps with a decline to a low point in 1994 followed by an increase. 95% upper and lower confidence intervals are shown (Figure 17). Year and season were both found to be significant, but the interaction was only significant for the analysis of positive trips. As a result, the final index was estimated with this interaction as a random factor using the glimmix program.

Gear Interaction

Evidence provided in a study conducted by Rosario and Sadovy (1991), indicates that the change in trap mesh size that occurred in 1994 may have a small effect on the catch rate of individuals. Sampling using different sized traps was undertaken for a year off of the West Coast of Puerto Rico and differences in catch by mesh size were noted. Overall catch rates for all species captured by weight using the 1.25-inch hexagonal mesh compared to the 1.5-inch square mesh were found to differ, though only slightly, with catch rates for the 1.25 inch hexagonal trap being slightly larger than those for the 1.5 inch square trap (Table 15). The study also found that the diversity of the species captured using the 1.5 inch square mesh trap was lower, compared to that captured by the 1.25 hexagonal inch trap (Rosario and Sadovy 1991).

For yellowtail snapper specifically, the study found that the 1.5-inch square mesh trap as compared to the 1.25 inch galvanized trap captured almost twice as many individuals (440 fish caught by the 1.5 inch trap and 230 fish caught by the 1.25 inch trap). One possible explanation for this may be that the 1.25 inch hexagonal trap design was found to be more flexible and has a higher gauge while the 1.5 inch square mesh trap is vinyl coated and is very rigid with a lower gauge. Despite the larger mesh size of the 1.5-inch square mesh trap, the rigidity prevents some fish of certain shapes and sizes from escaping. For the fishery independent data analyzed in this paper, it was found that more yellowtail snapper were sampled using the 1.25 inch hexagonal fish traps (the time period prior to 1994) (Figure 22), however it is hypothesized that this is a function of the effort employed and diversity of stations sampled rather than trap design (Table 8) (Rosario and Sadovy 1991).

Size and Maturity

Length frequency information is provided for yellowtail caught using hooks and traps. Length frequency was not further stratified beyond gear type because there were not enough observations. Those individuals captured with traps (Figure 21) show a better length distribution than those individuals captured with hooks (Figure 18), however this

may be due to the small number of yellowtail captured using hooks. Length distribution over time shows that throughout the time series individuals were evenly captured using hooks (Figure 19) and captured mostly in the first two years (1988 and 1989) using traps (Figure 22). Trend lines show little change over time and may be unreliable due to the small number of yellowtail sampled using hooks and the bunched distribution of yellowtail sampled (in 1988 and 1989) using traps. Length weight relationships were calculated for those individuals captured with hook and line (Figure 20) and traps (Figure 23). Maturity observations indicate that spawning may occur year round yet is higher in the spring (Figure 24). The majority of the individuals sampled were found to be running ripe and this may correlate with the fact that sampling efforts were highest in the spring (Figures 25 and 26).

Conclusion

Standardization of trap catch rates found that year and season were significant for the analysis of positive trips. Readers are advised to view the results of this analysis with caution due to the small number of yellowtail snapper sampled by both traps and hooks during this survey.

Literature Cited

Cass-Calay, Shannon L. and Monica Valle-Esquivel. 2003. "Standardized catch rates of silk snapper, *Lutjanus Vivanus* from the St. Croix U.S. Virgin Islands handline fishery during 1984 – 1997." SEDAR4-DW-10. Sustainable Fisheries Division Contribution SFD-2003-XXX. Southeast Fisheries Science Center, National Marine Fisheries Service, NOAA. 75 Virginia Beach Drive, Miami, FL 33149.

Cummings, Nancie (Ed.). "Stock Assessment Report: Caribbean Yellowtail Snapper, (*Ocyrurus Chrysurus*)." Southeast Data Assessment and Review VIII, Stock Assessment Report I, Section I.

Lo, N.C., L.D. Jackson, J.L. Squire. 1992. "Indicates of relative abundance from fish spotter data based on delta-lognormal models."

Rosario-Jimenez, Aida and Yvonne Sadovy. 1991. "The effect of fish trap mesh size on species composition and catch value in Western Puerto Rico." Proc. Gulf Carib. Fish Inst., 44: 5-28.

Tables and Charts

Species Captured Using Hooks	Number of Fish Captured Using Hooks
Red Hind	14853
Coney	8116
Sand Tilefish	3261
Squirrelfish	1225
Graysby	849
Longspine Squirrelfish	603
Silk Snapper	549
Blackfin Snapper	531
Vermilion Snapper	434
Black Durgon	351
Pluma Porgy	231
Yellowtail Snapper	46
Other	2143

Table 1: The number of fish sampled for the top 12 species captured during the survey period using hook and line.

Species Capured Using Traps	Number of Fish Captured Using Traps
Coney	1333
Red Hind	1191
Silk Snapper	374
Blackfin Snapper	307
Queen Triggerfish	288
Banded Butterflyfish	288
Foureye Butterflyfish	267
Vermilion Snapper	235
Princess Parrotfish	231
Squirrelfish	202
Yellowtail Snapper	198
Longspine Squirrelfish	145
Other	1235

Table 2: The number of fish sampled for the top 12 species captured during the survey period using traps.

Hooks Fished per Day	
Bin	*Frequency*
0	0
3	602
6	59
9	63
12	19
15	10
18	74
21	16
24	5
27	5
30	2
33	4
36	2
39	0
More	0

Hours Fished per Hook per Day	
Bin	*Frequency*
0	0
0.5	1
1	1
1.5	1
2	1
2.5	3
3	9
3.5	45
4	95
4.5	206
5	318
5.5	136
6	23
6.5	6
7	7
7.5	2
8	3
8.5	1
9	1
9.5	1
10	0
More	1

Table 3: The frequencies of number of hooks fished each day and the hours fished for each hook on a given day.

Traps Soaked per Day	
Bin	*Frequency*
0	0
3	0
6	32
9	1
12	147
15	228
18	8
21	16
24	2
27	0
30	33
33	0
36	0
39	0
42	4
More	0

Soaktime per Trap per Day	
Bin	*Frequency*
2	2
2.5	2
3	9
3.5	19
4	25
4.5	7
5	158
5.5	136
6	80
6.5	29
7	1
7.5	1
8	0
8.5	1
9	1
More	0

Table 4: The frequencies of the number of traps soaked each day and the hours each trap soaked on a given day.

Year	Hook-Hours	Hooks	Discrete Stations Sampled - HL	Days Sampled - HL
1988	3636.7	702	26	52
1989	3947.8	810	28	51
1990	5709.5	1161	17	71
1991	2231.31	447	2	46
1992	1475.25	360	44	106
1993	1480.98	339	31	74
1994	1505.73	324	35	106
1995	1402.14	300	26	94
1996	389.37	78	8	26
1997	894.06	177	38	57
1998	916.68	192	28	61
1999	1076.49	216	28	72
2000	385.59	81	15	27
2001	261.21	54	4	18

Table 5: The hook and line effort used each year and the number of different stations sampled each year (sampling of the same station on another day was not counted).

Month	Hook-Hours	Hooks	Discrete Stations Sampled - HL	Days Sampled - HL
1	2948.96	579	14	71
2	2711.54	563	15	89
3	2117.44	455	21	81
4	2923.61	609	34	83
5	3897.74	817	44	103
6	2259.82	481	44	88
7	760.56	159	25	44
8	1799.1	387	31	68
9	1823.79	411	34	73
10	1291.98	276	27	62
11	1551.06	270	23	52
12	1227.21	234	16	47

Table 6: The hook and line effort used each month over the survey period and the number of different stations that were sampled each month (sampling of the same station on another day was not counted).

Season	Hook-Hours	Hooks	Discrete Stations Sampled - HL	Days Sampled - HL
Fall	4070.25	780	66	161
Spring	9081.17	1907	122	274
Summer	4383.45	957	90	185
Winter	7777.94	1597	50	241

Table 7: The hook and line effort used each season over the survey period and the number of different stations that were sampled each season (sampling of the same station on another day was not counted).

Year	Soaktime	Traps	Discrete Stations Sampled - TR	Days Sampled - TR
1988	2510.45	535	27	53
1989	3311.1	660	27	47
1991	2183	425	2	26
1992	4906.55	981	39	82
1993	7905.75	1527	31	73
1994	5042.72	909	27	61
1995	4062.61	777	26	52
1998	2491.32975	464	18	31
1999	2990.43358	523	26	36
2000	657.81662	131	8	9
2001	57.6	12	1	1

Table 8: The trap effort used each year and the number of different stations that were sampled each year (sampling of the same station on another day was not counted).

Month	Soaktime	Traps	Discrete Stations Sampled - TR	Days Sampled - TR
1	1509.5501	289	11	20
2	2778.8399	532	11	38
3	3525.21294	637	20	44
4	4328.85	849	26	51
5	5566.90353	1087	36	71
6	4015.05015	754	34	54
7	1782.43324	324	20	26
8	2365.58328	469	24	37
9	3975.86681	773	29	39
10	2821.75	540	17	37
11	1657.2	331	19	26
12	1792.12	359	8	28

Table 9: The trap effort used each month over the survey period and the number of different stations that were sampled each month (sampling of the same station on another day was not counted).

Season	Soaktime	Traps	Discrete Stations Sampled - TR	Days Sampled - TR
Fall	6271.07	1230	44	91
Spring	13910.80368	2690	96	176
Summer	8123.88333	1566	73	102
Winter	7813.60294	1458	42	102

Table 10: The trap effort used each season over the survey period and the number of different stations that were sampled each season (sampling of the same station on another day was not counted).

Yellowtail Snapper Catch				
	Hook and Line		Traps	
Year	Weight (g)	Number of Fish	Weight (g)	Number of Fish
1988	495	2	11640	42
1989	3082	8	20599	102
1990	210	1	0	0
1991	925	1	3740	6
1992	1810	3	5425	11
1993	1350	4	1944	6
1994	2180	6	327	3
1995	2705	6	605	2
1996	1725	4	0	0
1997	425	1	0	0
1998	0	0	2330	9
1999	905	3	3661	11
2000	1135	4	1578	6
2001	410	2	0	0

Table 11: Yellowtail snapper catch using hooks and traps.

Nominal Yellowtail Hook and Line CPUE			
Year	Effort	Catch (g)	CPUE
1988	127.8	495	3.9
1989	680	3082	4.5
1990	81	210	2.6
1991	97.2	925	9.5
1992	40.5	1810	44.7
1993	81	1350	16.7
1994	72.27	2180	30.2
1995	102.99	2705	26.3
1996	60.3	1725	28.6
1997	15	425	28.3
1998		0	0
1999	43.59	905	20.8
2000	45	1135	25.2
2001	29.49	410	13.9

Table 12: Nominal hook and line catch per unit effort. Effort was calculated as the annual sum of hours fished times the number of hooks for positive trips (those days that captured yellowtail).

Nominal Yellowtail Snapper Trap CPUE			
Year	Effort	Catch (g)	CPUE
1988	1206.26	11640	9.6
1989	2134.00	20599	9.7
1991	672.00	3740	5.6
1992	408.50	5425	13.3
1993	480.00	1944	4.1
1994	222.30	327	1.5
1995	148.52	605	4.1
1998	390.00	2330	6.0
1999	553.62	3661	6.6
2000	233.27	1578	6.8

Table 13: Nominal trap catch per unit effort. Effort was calculated as the annual sum of the soaktime of each trap fished for positive trips (those days that captured yellowtail).

Standardization of Yellowtail Snapper Trap CPUE										
Year	StdErr	obcpue	obppos	nobs	cv_i	STDCPUE	LCI	UCI	estcpue	obscpue
1988	2.360	4.671	0.321	53	0.35	1.000	0.510	1.960	6.819	1.000
1989	0.981	4.247	0.447	47	0.36	0.402	0.200	0.804	2.738	0.909
1990										
1991	1.516	1.469	0.192	26	0.72	0.307	0.084	1.125	2.094	0.315
1992	0.597	1.127	0.085	82	0.64	0.138	0.043	0.442	0.938	0.241
1993	0.336	0.258	0.055	73	0.92	0.053	0.011	0.257	0.364	0.055
1994	0.132	0.073	0.033	61	2.12	0.009	0.001	0.125	0.062	0.016
1995	0.218	0.158	0.038	52	1.60	0.020	0.002	0.190	0.136	0.034
1996										
1997										
1998	0.394	0.971	0.161	31	0.90	0.064	0.014	0.300	0.436	0.208
1999	1.400	1.084	0.167	36	0.63	0.328	0.104	1.036	2.238	0.232
2000	1.639	2.254	0.333	9	0.87	0.275	0.061	1.241	1.875	0.482

Table 14: Annual standardized catch rates for yellowtail snapper captured using traps.

Mesh Size (in)	Trap Total Hauls	Trap Catch (# of fish)	Total CPUE (g/trap haul)
0.5 x 0.5	206	1227	159.60
1.25 hex	138	912	249.80
1 x 2	133	555	146.25
1.5 x 1.5	144	1018	219.34
2 x 2	190	539	140.72
2 x 3 galv.	207	155	50.60
2 x 3 vynl	58	65	65.34

Table 15: Fish trap catch and effort data by mesh size, where a single trap haul has a soak period of five to eight days (Rosario and Sadovy 1991).

Figures

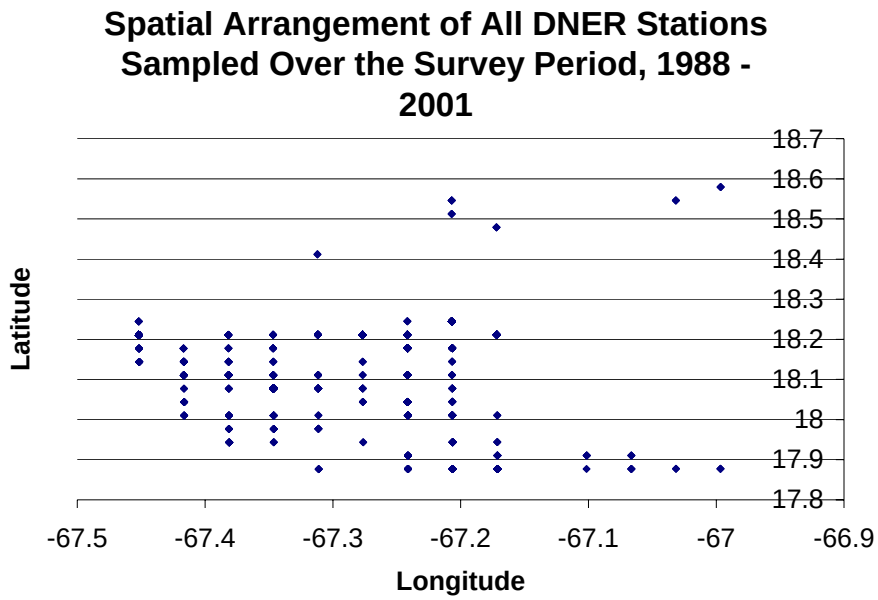


Figure 1: Spatial arrangement of the stations sampled off of the West Coast of Puerto Rico from Rincon to Cabo Rojo. Stratification by year and season showed similar results.

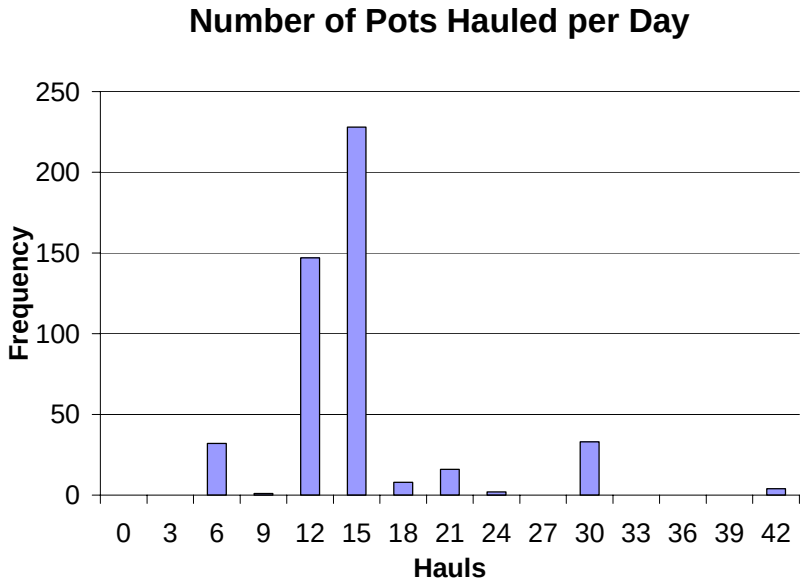


Figure 2: The frequency of fish traps hauled each day over the sample period.

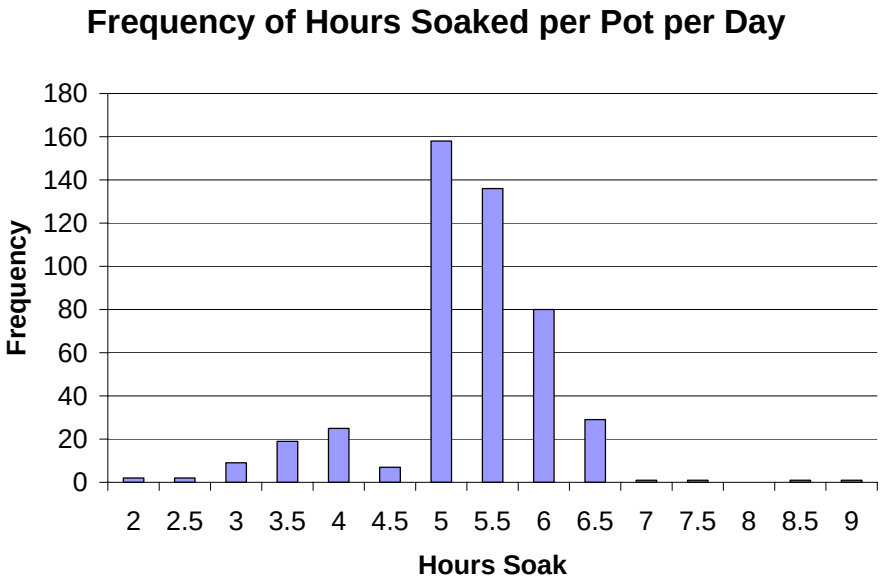


Figure 3: The frequency of hours soaked for each fish trap on a given day over the sampled period.

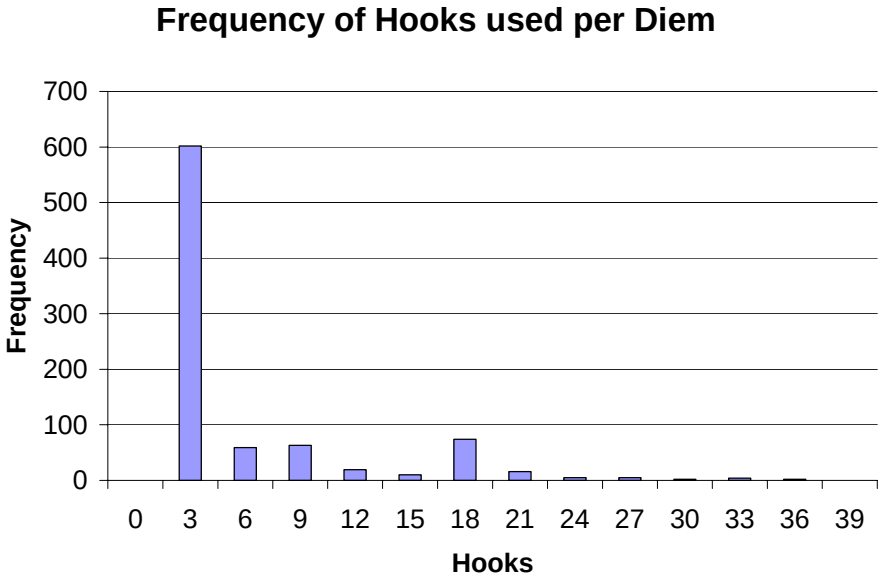


Figure 4: The frequency of hooks fished on a given day over the sampling period.

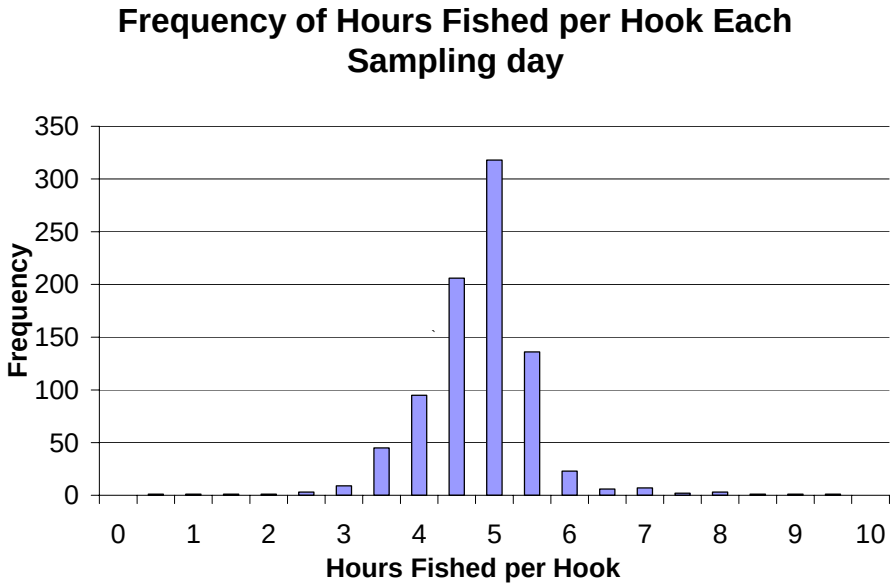


Figure 5: The frequency of hours fished for each hook on a given sample day.

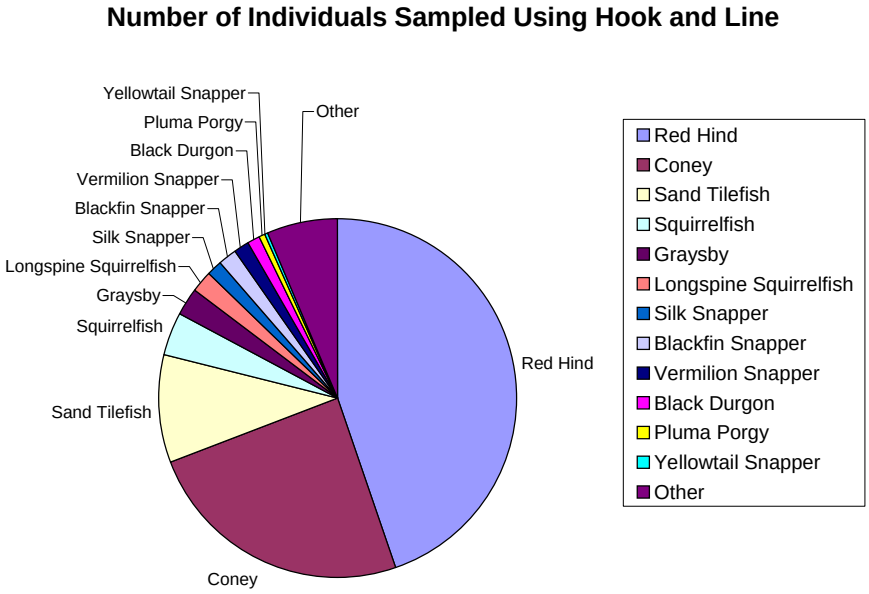


Figure 6: The number of fish sampled for the top 12 species captured during the survey period using hook and line.

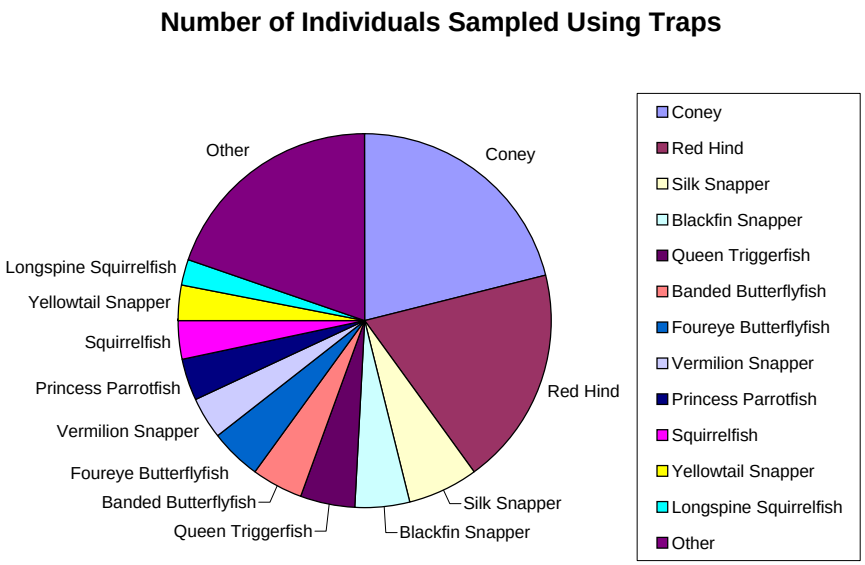


Figure 7: The number of fish sampled for the top 12 species captured during the survey period using traps.

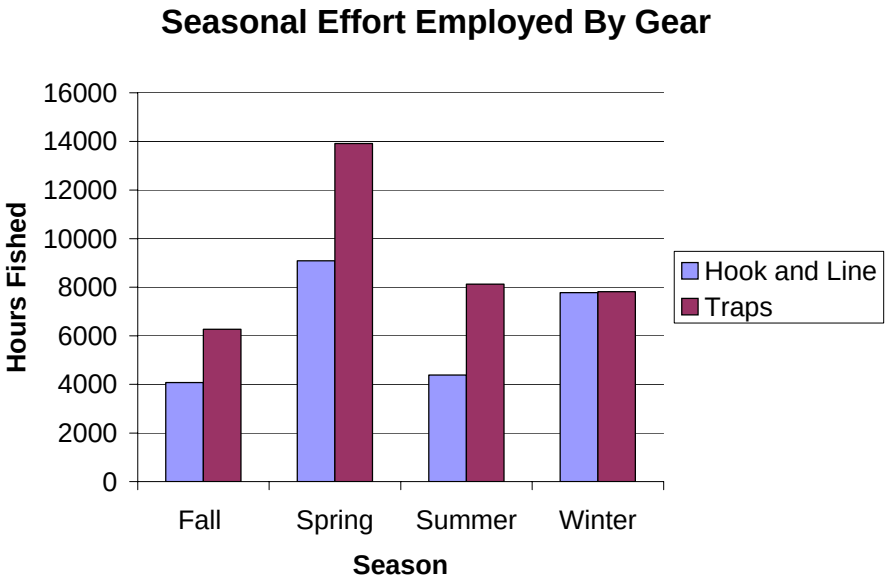


Figure 8: The sampling effort used each season with hooks and traps. Sampling effort for hooks is hook hours fished (hours time the number of hooks) while the sampling effort for traps is soak time (time each individual trap soaked).

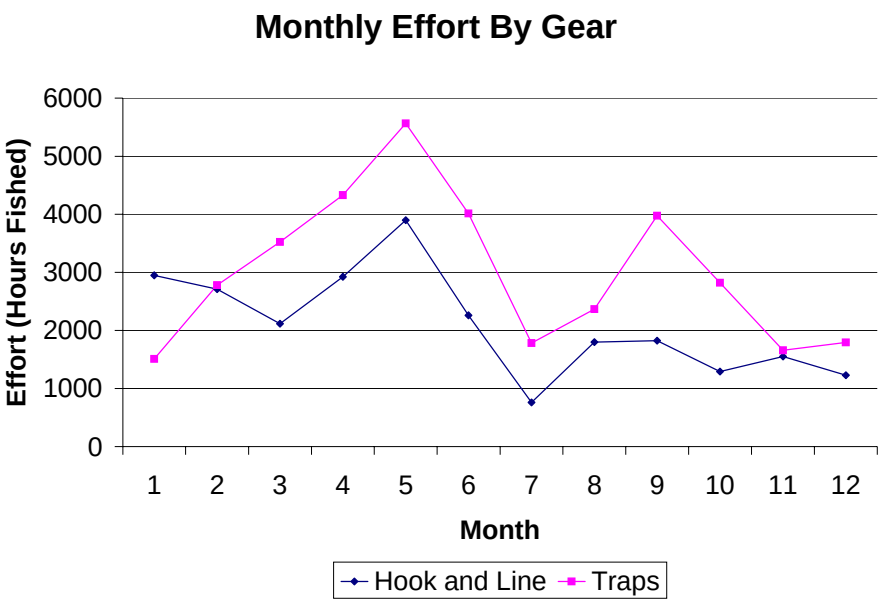


Figure 9: The sum of the effort used each month over the sampling period. Sampling effort for hooks is hook hours fished (hours time the number of hooks) while the sampling effort for traps is soak time (time each individual trap soaked).

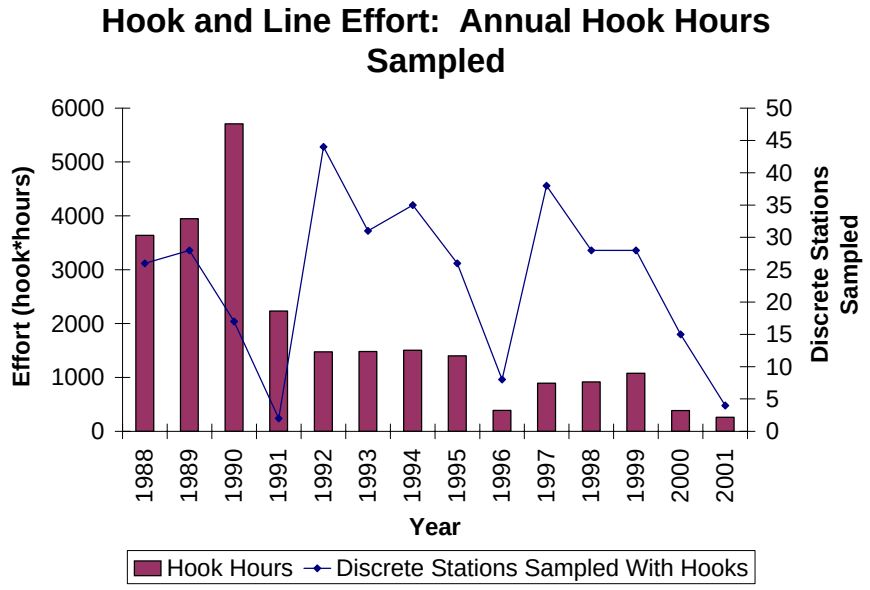


Figure 10: The sum of the hook hours fished for each year and the number of unique stations sampled that year, where instances of the same station being sampled more than once in a given year are only counted once.

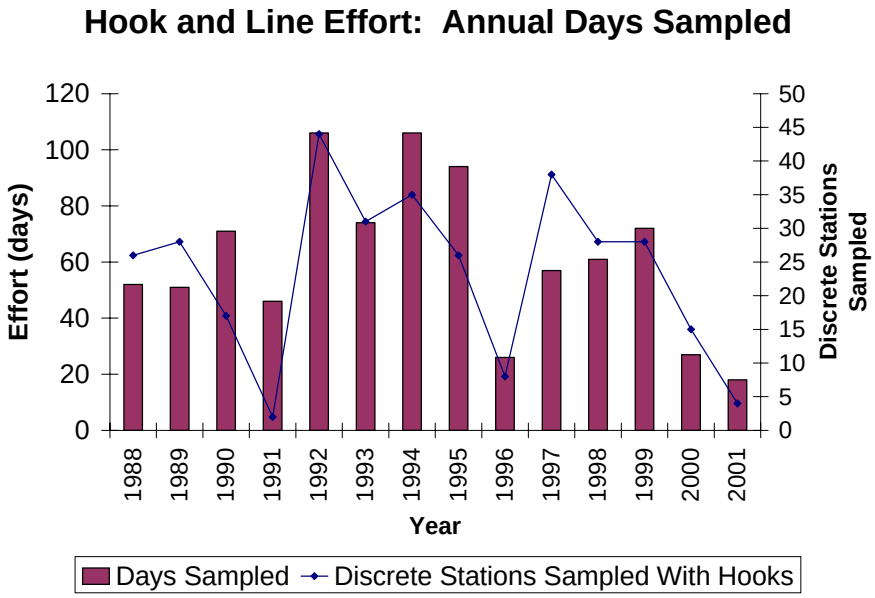


Figure 11: The sum of the days on which sampling took place for each year and the number of unique stations sampled that year, where instances of the same station being sampled more than once in a given year are only counted once.

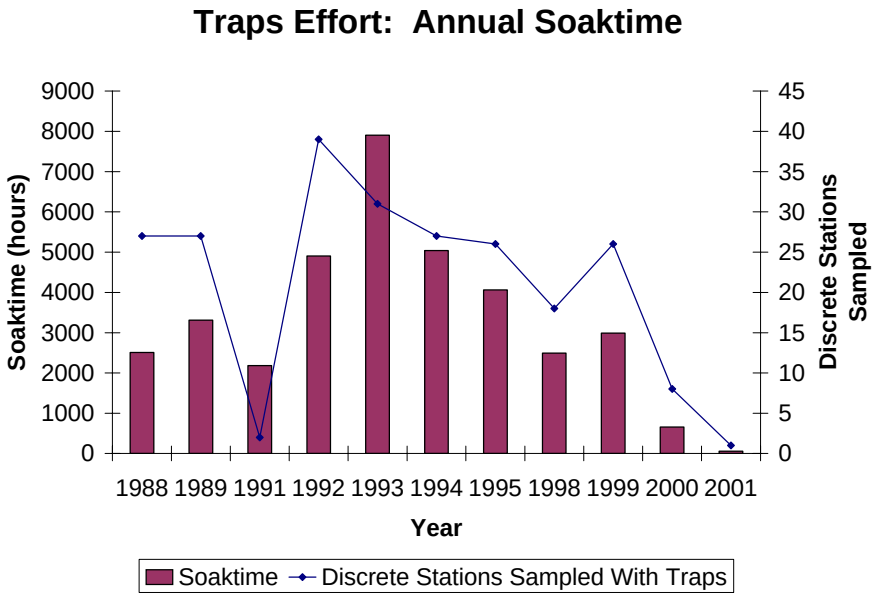
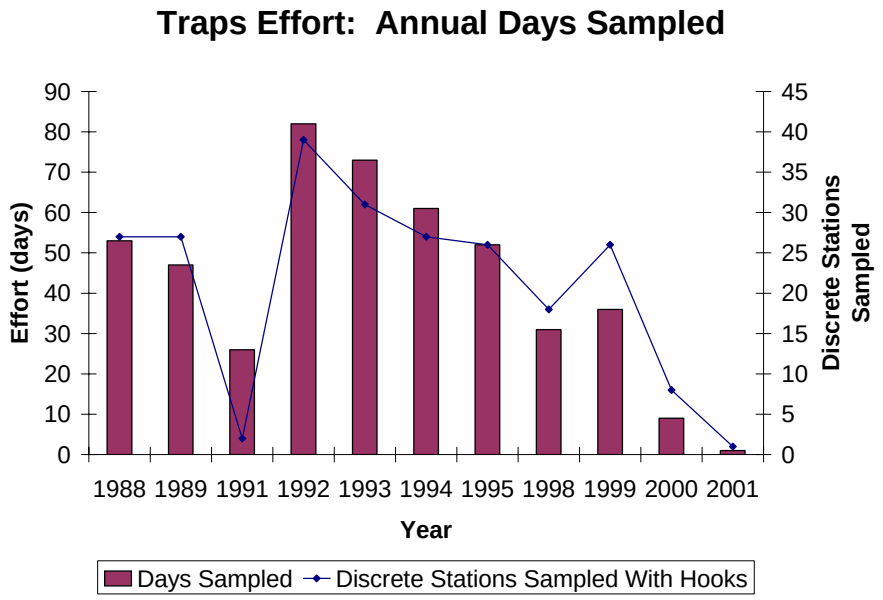


Figure 12: The sum of the trap soak time for each year and the number of unique stations sampled that year, where instances of the same station being sampled more than once in a given year are only counted once



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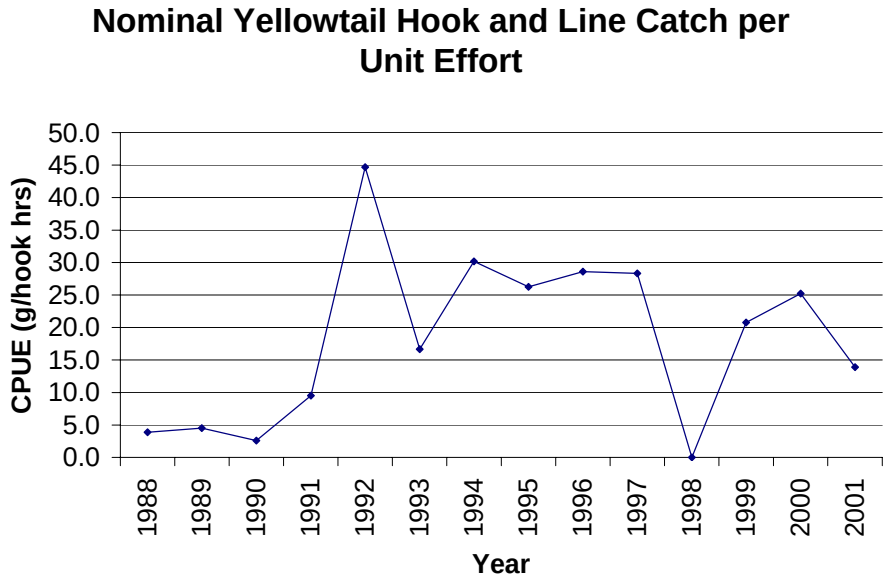

Figure 14: Nominal hook and line catch per unit effort calculated for positive trips only (those days on which yellowtail snapper were captured).

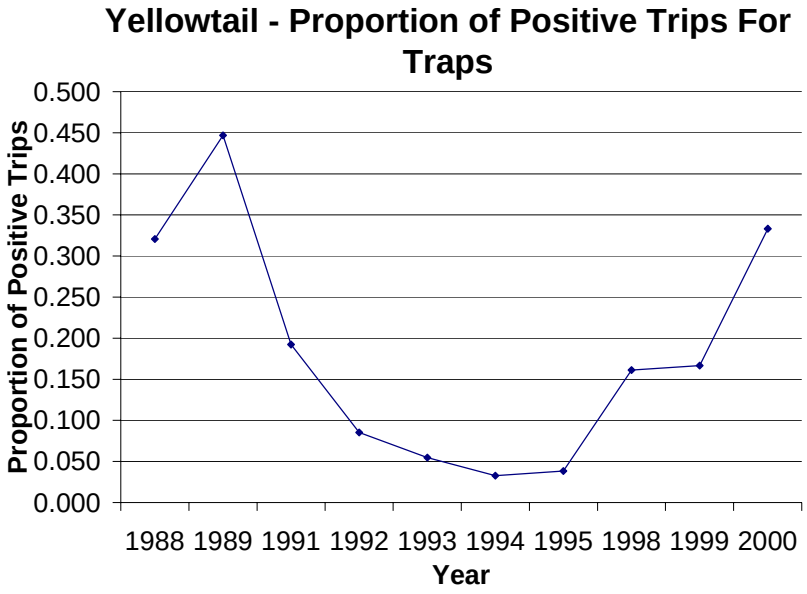

Figure 15: The proportion of positive trips (those days on which yellowtail were sampled) for traps.

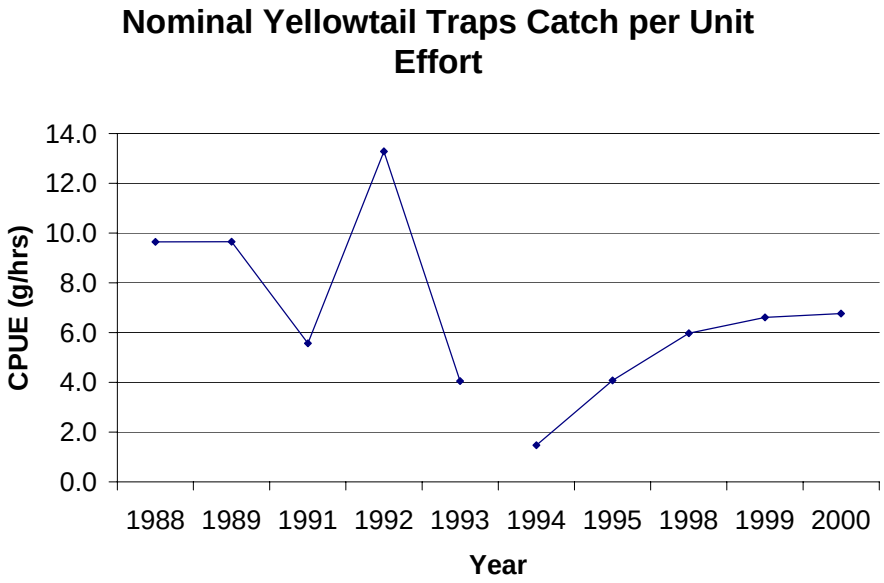

Figure 16: Nominal trap catch per unit effort calculated for positive trips only (those days on which yellowtail snapper were captured). The break in the curve represents the change in mesh size from 1.25 to 1.5 inches.

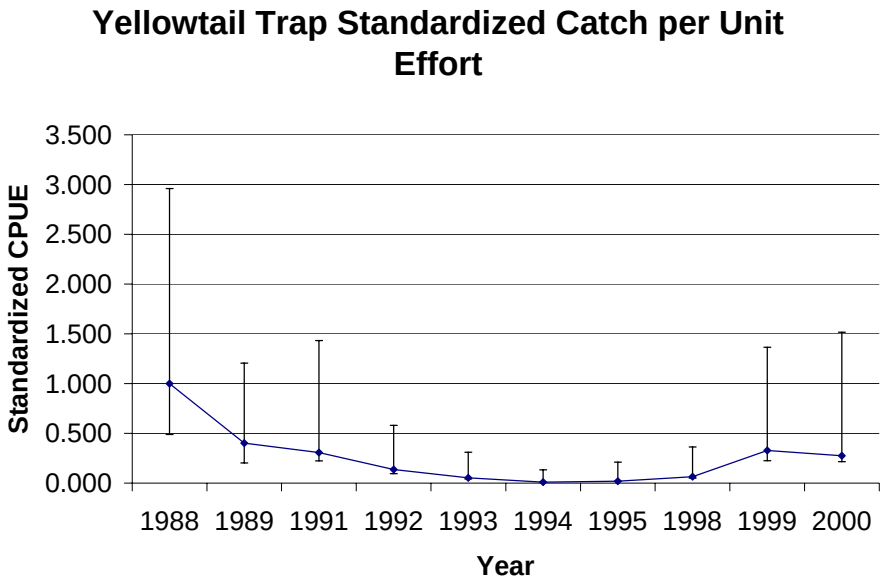

Figure 17: Standardized catch per unit effort for yellowtail snapper sampled with traps calculated for positive trips.

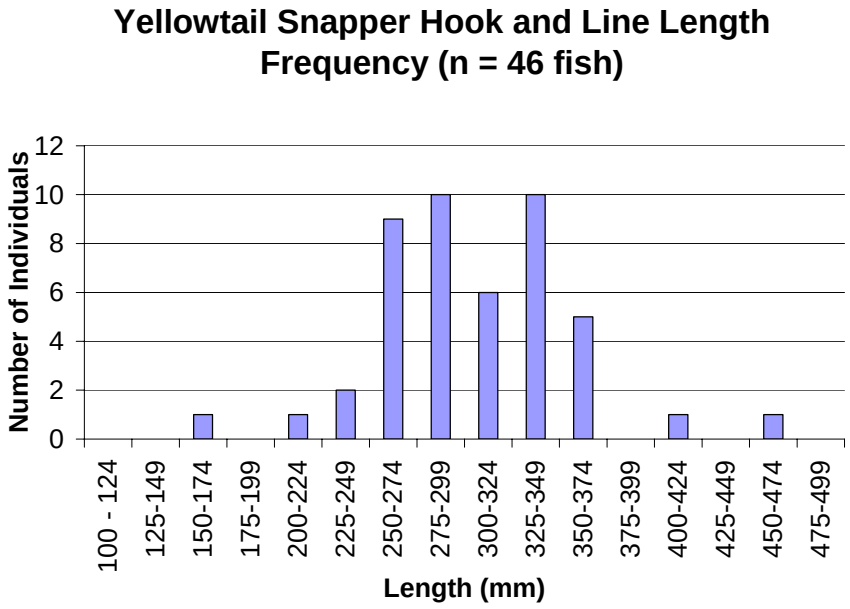

Figure 18: The length frequency of yellowtail snapper captured using hook and line.

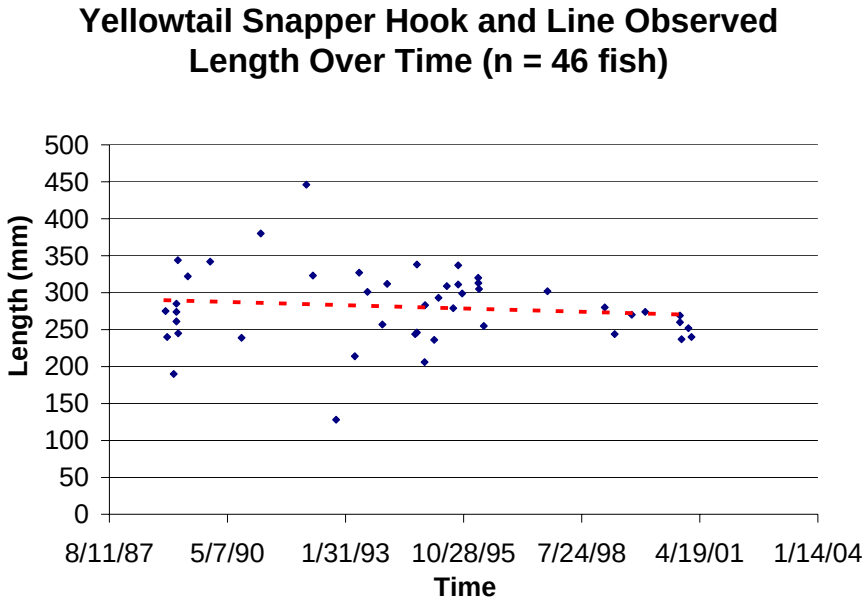

Figure 19: The observed lengths of individuals captured over time using hook and line (R^2 = 0.0146).

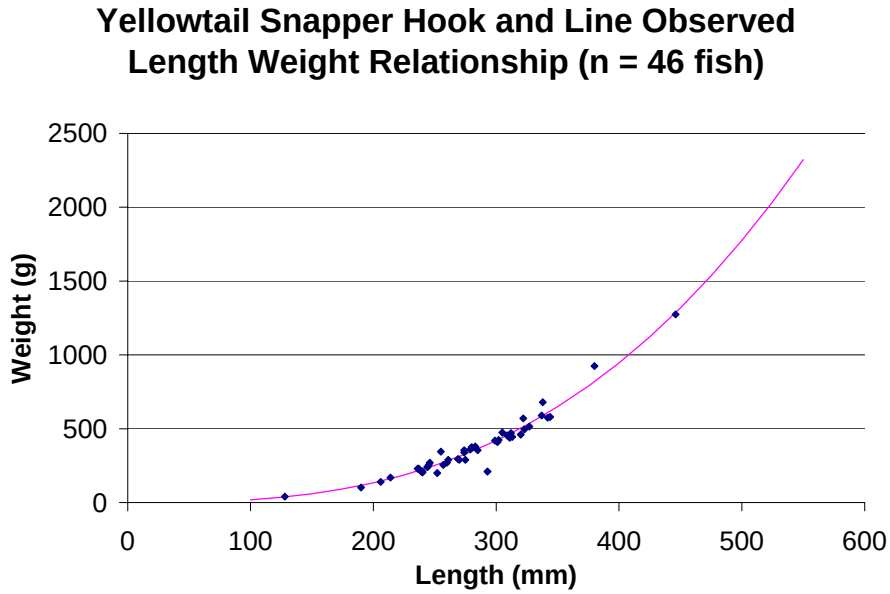

Figure 20: Yellowtail snapper length weight relationship for those individuals captured using hook and line (a = 4.37 x 10^{-5}; b = 2.82).

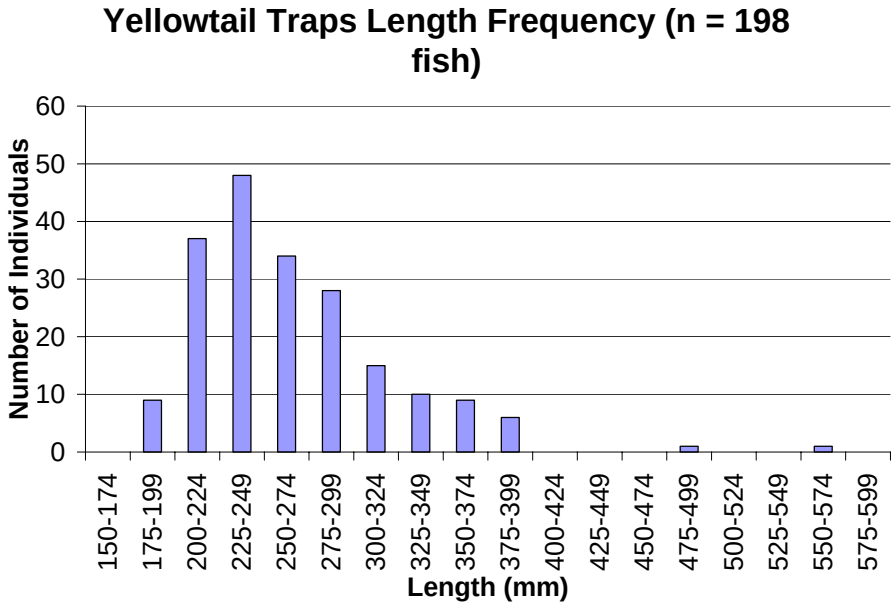

Figure 21: The length frequency of yellowtail snapper captured using traps.

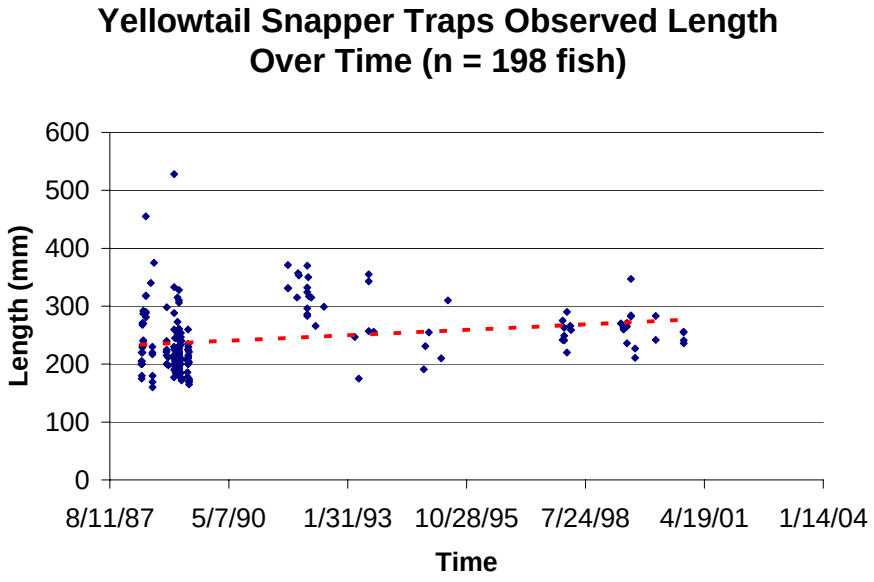

Figure 22: The observed lengths of individuals captured over time using traps (R^2 = 0.0522).

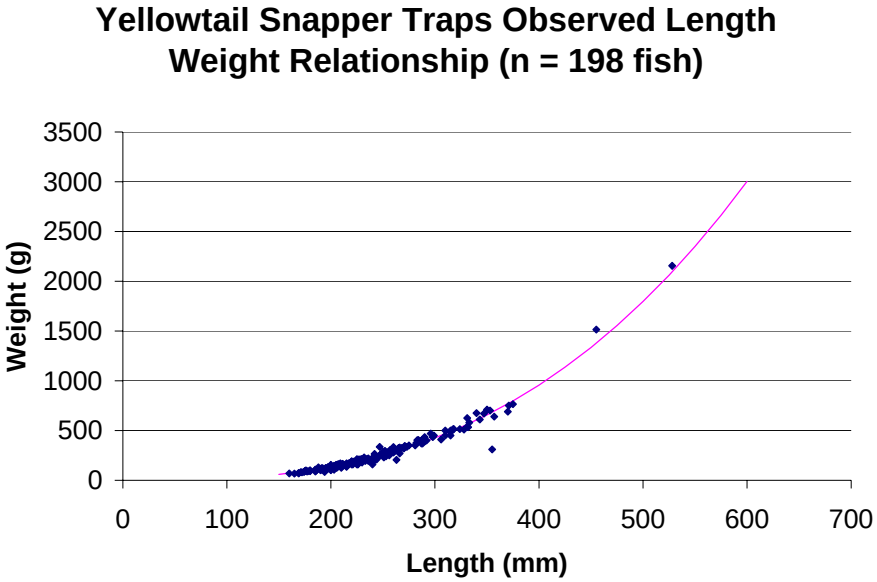

Figure 23: Yellowtail snapper length weight relationship for those individuals captured using traps ($a = 4.42 \times 10^{-5}$; $b = 2.82$)

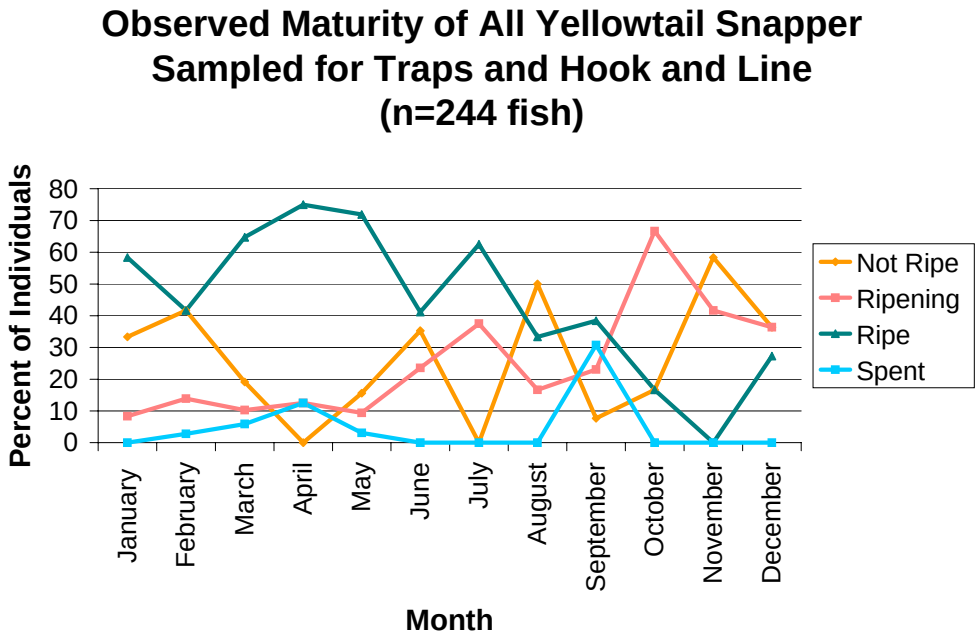

Figure 24: Observed maturity states for individuals captured using traps and hooks.

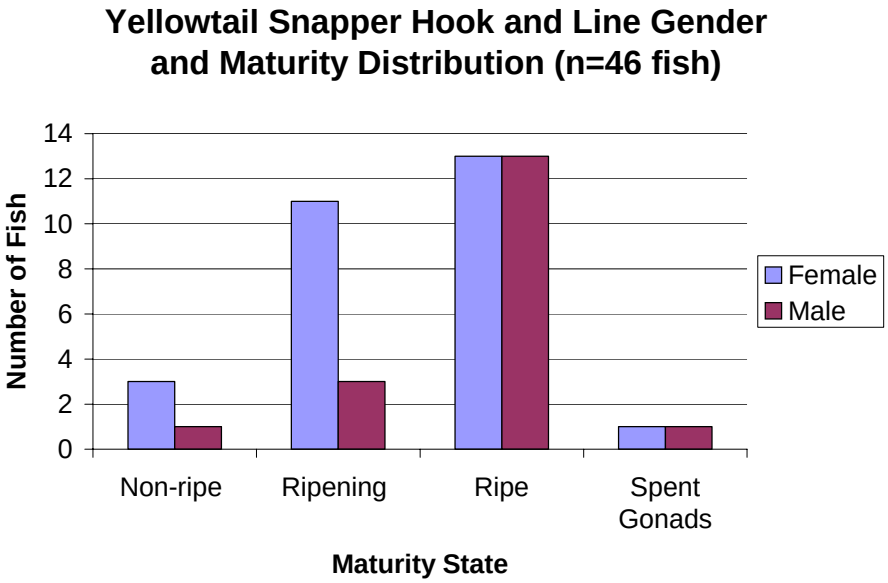

Figure 25: Gender and maturity distribution for yellowtail captured using hooks.

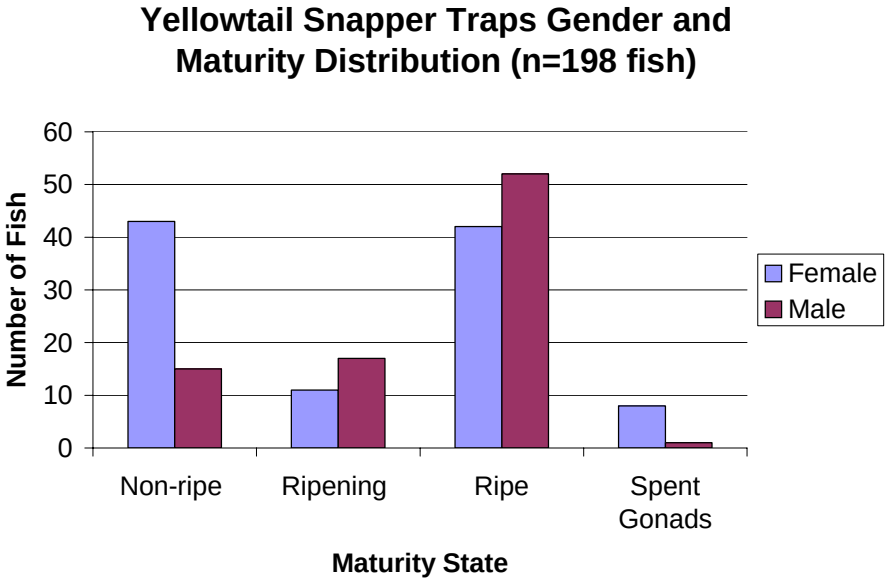

Figure 26: Gender and maturity distribution for yellowtail captured using traps