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Standardized Catch Rates of Spiny Lobster (*Panulirus argus*) Estimated from the Puerto Rico Commercial Trip Interview Program (1980-2003)

by

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ABSTRACT

NOAA Fisheries Trip Interview Program (TIP) data from Puerto Rico (1983-2003) were used to construct standardized indices of abundance for spiny lobster, *Panulirus argus*. Separate indices were estimated for each main gear type: dive, fish traps and lobster traps, using a Delta-Lognormal approach. This method combines two general linear models, a binomial model fit to the proportion of positive trips, and a lognormal model fit to catch rates on positive trips. Effective effort was approximated by considering zero trips through the construction of species assemblages by gear. The lobster fishery in Puerto Rico is concentrated around the Southwest shelf, with Diving being the most important fishing method. The fishery operates year-round, but a peak in relative abundance was observed during the Winter and early Spring months. Consistent trends were not observed across the fisheries examined, but for the overall fishery, a slight increase abundance was suggested. CPUE rates from the Puerto Rico TIP program may be underestimated due to incomplete trip samples.

INTRODUCTION

The Trip Interview Program (TIP) collects biostatistical data on spiny lobster via port sampling agents conducting personal interviews with commercial fishers at landing sites and sale locations. TIP surveys also include information about trip specific catch and effort. All sampling is conducted by or through voluntary cooperation of the fishers.

TIP data from Puerto Rico is available from years 1983 through 2003.

METHODS

Data Description

TIP data were utilized to estimate CPUE as the mean weight (in pounds) of spiny lobster per fishing trip by gear type. Indices were estimated for the three main gear types used to harvest lobster: DIVE (Hand/Spear/Diving), FISH TRAPS (Fish Pots/Traps), and LOBSTER TRAPS. Only those records with a single gear type recorded were used.

It is important to note that the TIP data from Puerto Rico does not contain any information to calculate the proportion of the catch sampled by trip, so it is impossible to expand the samples to the total landings. In order to conduct this study, it was assumed that the whole catch is sampled on any particular interview, so the sum of all individual weights should serve as a proxy to calculate the trip landings. If all the catch is sampled, then also the catch composition –and species assemblages- could be drawn from the information available in TIP.

Data Conversions

The TIP data for spiny lobster include a number of length and weight measurement types and units of measurement. All length data were converted to carapace length (CL) in millimeters, and individual weight was converted to grams. In cases where weight information was missing, a length-weight relationship from Florida (FAO, 2001) was used to perform the conversion:

$$W_T = 2.519\ L_C^{\ 2.71}$$

where W_T= Total weight and L_C= carapace length.

Identifying Trips Associated with Spiny Lobster

For a studied species, defining effort from the TIP data set is not straightforward, given the multi-specific nature of the Puerto Rico –and other U.S. Caribbean- fisheries. The data set contains information about species caught, but not regarding the species targeted. Effective fishing effort (i.e., including trips that landed lobster and trips that may have targeted this species but did not catch it, zero trips) was estimated using the species assemblage method developed by D. Heinemann and described in Sass-Calay and Bahnick, (2002) and in the NOAA-Fisheries SEDAR4-DW report (2004).

An association statistic (DH) was computed to determine the species often landed in association with *Panulirus argus* and other (unidentified) members of the same family, Panuliridae:

$$DH = \frac{N(S,x)\ \ N(s)}{N(x)\ N}$$

where $N(s)$ is the number of trips that caught the studied species; $N(x)$ is the number of trips that caught species x; $N(s,x)$ is the number of trips that caught the studied species and species x; N is the total number of trips. The statistic gives less weight to species that are more abundant but unreasonably high scores are given to species caught very infrequently, but alongside the studied species (i.e., small sample size). Species selection used a minimum co-occurrence sample size of (i.e., $N(s,x) \geq 30$ trips), and the association index values that scored the highest. Trips that landed the species from the assemblage were included for catch rate analysis.

Definition of Fishing Effort

In addition to 'trips', units of effort must also be defined. The following units available in TIP were considered: the number of traps, the number of gear (divers or dives per trip), and the hours fished or soak time. Unfortunately, none of this information was complete in the database across the whole time series or across platforms, so the best available unit was the number of trips. Each 'sequence number' was assumed to correspond to one fishing trip. Some of those effort units were however considered as categorical variables.

CPUE Analysis

A Generalized Linear Mixed Model Approach (GLMM) was used to estimate relative indices of abundance. Two different methods were used, depending on the characteristics of the data for each gear: a conventional GLM model and a Delta-Lognormal model (Lo et al. 1992). The GLM model uses a linear model to describe only the positive CPUE observations of the target species. The delta-lognormal model combines the proportion of positive trips (trips that landed spiny lobster) and positive catch rates on successful trips to construct a single index (Lo et al., 1992).

The influences of the following categorical variables on relative abundance were investigated: year, season (Winter, Spring, Summer, Fall), coast (North, South, East, West), gear (dive, fish traps, lobster traps), number of gear (number of traps, number of dives), hours or days fished (soak time from trap set to haul, hours diving), and the average depth of fishing (for dive trips).

A step-wise regression procedure was used to determine the set of factors and interactions that significantly explained the observed variability in each model component. Factors were added sequentially to the model based on the percentage reduction in deviance per degree of freedom ($\geq$1.0%), using a χ^2 (Chi-square) test ($p<0.05$). Interactions between factors were evaluated under the same criteria, using a GLM procedure (GENMOD, SAS Institute Inc., 1999-2001). To illustrate this procedure, deviance analysis tables for catch rates in pounds are presented for the first index developed (i.e., Delta-Lognormal Model, Puerto Rico combined fisheries), in Table 9.

The final GLM or delta-lognormal model was fit to the CPUE data using algorithms developed by Ortiz et al. (2000, 2001) that incorporate the GLIMMIX and MIXED procedures from SAS®. An examination of the data, the assumptions used for analysis and the relative indices of abundance developed are described below.

RESULTS

General Observations and Assumptions

The Puerto Rico TIP database contains a total of 10,821 interviewed trips during the period 1980-2003. Since the program's inception, sampling has been consistent, averaging approximately 500 interviewed trips by year. From the multi-species fishery, handlines and fish traps report most of the catch, with 28 and 29%, respectively, followed by diving gear (18%).

Of the 10,821 interviewed trips 2,268 reported spiny lobster (Table 2), with 3 main gears: DIVING (spears, scuba, free diving, hand), FISH TRAPS (or 'pots') and LOBSTER TRAPS. Approximately 81% of the dive trips catch lobster, 65% of the lobster trap trips, and 19% of the fish trap trips. Of the lobster trips by gear, 68%, 26% and 2% of the trips use fish traps, diving, and lobster traps, respectively (Table 3, Figure 1). Based on this information, four standardized CPUE indices were developed, one for the overall fishery and for each of these main gears. A brief diagnostic of the data is given below.

The majority of the Lobster observations in TIP (65.7%) do not appear to come from targeted trips, that is, the trip target species (NODC21) is different from the sampled species (NODC41) in 65.7% of observations. Then, target information is unclear and assumptions have to be made to conduct CPUE analysis. The total trip landings and the total sample weight are frequently missing, so there is no way to estimate the proportion of the catch that the sample of each species represents or to expand the sampled proportions to total landings. The same applies in the analysis of species composition or to the identification of species assemblages.

Attempts were made to estimate the proportion of the catch sampled for spiny lobster, but several problems were encountered:

1. Many outliers were (coming from errors in individual weights of other species) were found in preliminary calculations.

2. Individual weights and the sum of weights for all other species would need to be known, corrected, added to Lobster weight and then compared to the (Total) Landing weight (WEIGHT21).

3. Target species is not indicated with any precision, landing weight is often missing and therefore cannot compare targeted Lobster trip landings vs added sample weight.

4. Therefore, cannot compare Lobster sample weight vs. landing weight in Targeted trips.

The location fished is generally not provided in the TIP database, but can be inferred from the reporting or sampling ZIP codes. With these, the fishing center, the municipality, and the coast where catch is landed may be known. To simplify assumptions, ZIP code locations were assigned to 4 coasts: North, South, East, and West.

Species Assemblages

Estimation of the degree of species association with spiny lobsters was based on association with the primary gear ('Gear1') used in a fishing trip. This method was only needed to estimate targeted trips for the Fish Trap fishery, as the proportion of lobster harvested with dive gear and lobster traps was very high and all the trips were selected for CPUE analysis. However, species associations were examined for all gears. Lists of species assemblages for spiny lobster (*Panulirus argus* and unclassified Panuliridae) are presented in Table 4, 5, and 6.

The criteria used to select the species associated with lobster included large DH statistic values and co-occurrence sample size of 95 (i.e., $N(s,x) \geq 95$) for fish traps and of $N(s,x) \geq 30$ for the dive gear. Sample size for lobster traps was too small to establish significant associations. In general, the DH statistic for species harvested with Fish Traps was not too high, indicating that although a number of species are associated with lobster, they do not occur together very frequently.

Trip Selection

To select Trips by Gear for use in CPUE analysis:

1. **Hand/Spear/Diving (DIVE)-** Keep all dive trips, as lobster trips represent approximately 81% (1539 of 1900) of all trips;
2. **Lobster Traps (LOBTRAPS)-** Keep all Lobster Trap trips, approximately 67% (48 of 72) are lobster trips;
3. **Fish Pots/Traps (FISHTRAPS)**- Use species assemblage method, as only 26.7% (842 of 3158 trips) are Lobster trips.

Absolute zero trips, with no landings (or samples) of any species, were considered in the analyses, as they may represent actual effort.

Definition of Fishing Effort

In addition to 'trips', the units of effort must also be defined. The following units available in TIP were considered as possible alternatives to the Number of Trips; units vary by Gear Type:

1. Number of gear= number of DIVES or number of traps SET, for diving trips, and fish/lobster traps, respectively.
2. Gear quantity = number of DIVERS or number of traps HAULED.
3. Soak time= Time the gear is in the water fishing; in hours fished or hours from set (time gear begins fishing) to haul (time at which the gear is retrieved), or in hours diving.
4. Depth= The average depth (initial and final) at which fishing occurred, in fathoms (1 fathom=6 feet).

The number of lobster trips by Gear Type (Table 3) and effort unit (Table 7) show that there is a large number of zero or missing observations in the effort units, which would exclude a large proportion of positive lobster trips from CPUE analysis. For diving trips, the depth fished is a good candidate for inclusion as an explanatory variable (66% of depth observations present), and will be used as a second alternative for trip selection. For trips that deployed traps, the number of traps hauled would be a good option, but sample size is small. In the case of Lobster traps, soak time can be used (information in 89% of the data). The mean values and variance of the number of gear, time fishing and depth fished by gear type are given in Table 8.

RELATIVE ABUNDANCE INDICES

Delta-Lognormal and GLM Models were applied to estimate relative indices of abundance. In the selection of explanatory variables, only interactions that contained significant fixed factors were included in the model. Inclusion of other significant interactions (fixed and random) did not improve model fit, and caused larger deviations from the observed CPUE values.

Diagnostics of the TIP database indicated that a number of restrictions must be imposed on the data for further analysis, depending on the index being developed:

1. Combined Lobster Gears (DIVE/FISH TRAPS/LOBSTER TRAPS)

Diagnostics of categorical variables for all the trips selected are illustrated in Figure 2. The following observations and restrictions were considered to develop a well-balanced sampling design:

1) Included years 1984-2003, few positive trips present before this period.
2) Included all Diving and Lobster Trap trips; and only Fish Trap trips of lobster and associated species, determined by the association index.
3) Removed outliers (records with Lobster catch >100lb and <1lb), based on 90% quantiles
4) Removed records with undefined landing or reporting area (i.e., no Coast information).
5) Area fished grouped into coasts: Northeast, South, West.
6) Months of the year were grouped into seasons: *i)* Winter, *ii)* Spring, *iii)* Summer and, *iv)* Fall. A slight seasonality was observed in the lobster landings, with a peak in the Winter and Spring.
7) The positive observations represented approximately a 48% of all the data.
8) Preliminary runs used two approaches to estimate relative indices of abundance:
   - **a)** Delta-Lognormal Index including zero trips and,
   - **b)** Generalized Linear Model Index, using only positive lobster trips.

9) Explanatory variables considered: year, season, gear, coast

10) The final model selected was (deviance tables shown in Table 9):

```
SUCCESS= YEAR+ GEAR + YEAR*GEAR
LNCPUE= YEAR2+COAST2+ YEAR2*COAST2
```

For comparative purposes, a Delta-Lognormal and a GLM model were applied. The respective relative abundance indices are provided in Table 11 and 12; diagnostics and indices are illustrated in Figure 3, 4, and 5. An increasing trend in relative abundance was observed, from approximately 5 lb/trip in 1984 12 lb/trip in 2003, with large annual fluctuations over the whole period (coefficient of variation averaging 30%). It is worth examining the sources of this variation, which may be attributed to large differences among gears. This upward slope disappeared when only the positive trips were examined under the GLM model: fluatuations were smaller, around a mean, constant value of 13 lb/trip, and variability was reduced to approximately 20%. This comparison indicates that the proportion of lobster trips has increased (i.e., increased targeting), whereas the actual CPUEs from positive trips have remained stable.

In addition, significance of the Gear factor suggests that each fishery should be analyzed separately, as each gear is likely to produce differences in catch rates. Thus, standardized CPUEs were developed for the Dive gear, Fish Traps, and Lobster Traps in the sections tat follow.

2. DIVE GEAR (Hand/Spear/Dive)

Observations and restrictions imposed:

1) Only Dive gear.
2) Years 1989-2003. Between 1985-1988 no lobsters were sampled or only few months sampled per year.
3) Removed records with no Coast information
4) Coasts North and East grouped into Northeast due to small sample sizes.
5) Performed two types of analysis: including **Depth** as a factor and not.
6) In the analyses including **Depth**, the data restricted to trips where depth information was present; average depth was calculated when possible (End Depth-Start Depth) or either one was used. Average dive depth is 10.6 Fathoms (approx. 65 ft). The Depth range (in Fathoms, 1Fathom=6 feet) was classified into the following categories (depth distribution of dive trips is included in Figure 2).

Depth Range (Fathoms)	Category
0 < Depth < 6	1
6=< Depth< 7.25	2
7.25 =<Depth <12.5	3
Depth> 12.5	4

7) An 84% of the observations were positive trips (Success Level 0= Zero Trips; 1=Positive Lobster Trips)

Level	Count	Prob
0	285	0.16221
1	1472	0.83779
Total	1757	1.00000

8) **Dive Model**. Explanatory variables considered: year, season, coast. The final model selected was (deviance tables not shown):

```
LNCPUE= YEAR +COAST + YEAR*COAST
SUCCESS= YEAR + COAST
```

The Delta-Lognormal index statistics for the Dive Model are provided in Table 13 and Figure 6**.** No clear trends in relative abundance were observed, index values have fluctuated around 11 lb/trip since 1989, with an average variation of 18%.

9) **Dive Model with Depth.** Explanatory variables considered: year, season, coast, depth. The final model was:

LNCPUE= YEAR + COAST +DEPTH + YEAR*DEPTH+ YEAR*COAST

SUCCESS= YEAR + COAST + YEAR*COAST

The Delta-Lognormal index statistics for the Dive-Depth method is provided in Table 14 and Figure 7**.** No clear trends in relative abundance were observed, index values have fluctuated around 11 lb/trip since 1990. The ga observed in 1996 is due to incomplete data. **Depth** of diving had a significant effect upon the catch rates.

3. FISH TRAPS

Restrictions:

1) Years 1984-2003 considered. There were few samples before 1984; and sample size is small from 1988.
2) Selected associated fish trap trips with species assemblage method (Table 4).
3) Delete COAST=Unknown (99 trips of 2496)
4) Limit positive lobster observations to catch > 0 and =<100.
5) Successful trips (Level 1) corresponded to 23% of the observations.

Level	Count	Prob
0	1714	0.77277
1	504	0.22723
Total	2218	1.00000

6) Factors considered: year, season, coast. The final model was:

LNCPUE= YEAR

SUCCESS= YEAR + COAST + SEASON

The positive trips were only explained with the year factor, which suggests that the methods, location, and time of fishing for the species in the fish trap assemblage may differ significantly from the trips that truly target spiny lobster. Standardized index statistics for this fishery are given in Table 15 and depicted in Figure 8. A slight upward trend in relative abundance was observed, from 3 lb/trip in 1984 to 12 lb/trip in 2003, with large fluctuations between years. Variability within each year also increased significantly toward the later years, to approximately 40% coefficient of variation.

4. LOBSTER TRAPS

Restrictions:

1) All lobster trap trips included.
2) Years 1991-2001; no data for years 1995-1996.
3) Grouped Coasts North and West due to small sample sizes.
4) Limit positive lobster observations to catch > 0 and =<50 lb/trip.
5) 63% of the trips were successful (Level 0= Zero Trips; 1=Positive Lobster Trips):

Level	Count	Prob
0	25	0.36765
1	43	0.63235
Total	68	1.00000

6) Overall sample size was small (N=68), the binomial model to explain the proportion of positive trips did not converge; therefore, only the positive observations were modeled using a standard GLM.
7) Explanatory variables considered were year, coast, season. The final positive model was:

LNCPUE= YEAR + COAST +YEAR*COAST

GLM index values for the Lobster Trap fishery are presented in Table 16 and Figure 9. The data available for this index were sparse and inconsistent, but a close examination of the statistics suggest smaller values before 1995 (averaging 15 lb/trip) than after 1997 (averaging 20 lb/trip). During both periods, relative abundance declined and variance was high (approx C.V.s of 40%).

CONCLUSIONS

Summaries of all the indices developed in this study are presented in Table 17 and 18 and Figure 10 and 11. A comprehensive analysis of the results suggests that the lobster fishery in Puerto Rico is concentrated around the Southwest shelf, with Diving being the most important method used to harvest lobster. The fishery operates year-round, but some seasonality was observed, with higher relative abundance around the Winter and early Spring months. This coincides with the Winter migration that has been reported in this region.

Analysis of the overall Puerto Rico lobster fishery indicates that the catch rates from positive trips have remained fairly constant over the period 1984-2003, at around 13 lb/trip, but that targeting of this species has increased significantly, as suggested by the Delta-Lognormal index. Clear differences were observed among gears, with increasing rates in the fish trap fishery, compared to flat rates in the dive fishery and declining rates in the lobster trap fishery. These contrasting, and often contradicting results suggest that each fishery operates with distinct efficiencies, selectivities, and catchabilities. The least efficient gear in capturing lobsters were the fish traps, but this was expected, as this gear targets mostly fish species and therefore a large proportion of zero (lobster) trips occur. It is possible that the species assemblage method used to identify fish trap trips is rather subjective or arbitrary, so estimation of effective fishing effort for lobster may have been over or under-estimated.

The largest catch rates were observed with lobster traps, but this method is not very common in Puerto Rico. The preferred method is diving, which showed a very stable (and flat) rate over time, suggesting that relative abundance has remained constant over the twenty-year period. However, if trendlines were added to all the indices developed in this study, the general trend would be toward an increase in abundance.

It is important to note that the major assumptions of this study may not hold, that is, that sampling has in fact been irregular, that the catch is not sampled completely, and that therefore the samples are not representative of the total landings. The low catch rates observed, even in the targeted lobster fisheries (dive and lobster traps) indicate that this database may not be too reliable for catch rate analysis, unless targeting information and the proportion sampled start being recorded regularly.

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Table 1. Total interviewed trips by year and gear type contained in the Puerto Rico TIP database (19810-2003).

Year	Number of Interviews	Hand/Spear/ Diving	Gillnets	Handlines	Longlines	Lobster Traps	Seine	Fish Traps	Troll	Other
1980	**34**	7	0	0	0	0	0	27	0	0
1983	**193**	7	6	21	0	0	1	158	0	0
1984	**703**	16	8	74	1	3	1	598	2	0
1985	**385**	10	4	73	0	0	0	298	0	0
1986	**551**	11	53	97	0	0	20	369	1	0
1987	**402**	27	32	65	0	5	5	249	18	1
1988	**397**	31	56	111	6	5	8	114	48	18
1989	**559**	107	102	114	20	0	11	166	30	9
1990	**575**	131	110	125	36	0	14	101	57	1
1991	**958**	139	58	475	39	7	8	164	66	2
1992	**978**	154	47	200	2	4	47	167	357	0
1993	**614**	126	37	263	4	4	16	92	72	0
1994	**270**	45	23	81	0	1	9	48	63	0
1995	**466**	134	18	173	2	0	3	56	80	0
1996	**334**	105	37	0	2	0	6	57	125	2
1997	**275**	56	39	108	0	3	6	53	9	1
1998	**447**	119	56	143	3	9	18	60	39	0
1999	**563**	145	60	171	4	7	23	91	58	4
2000	**486**	130	52	146	4	5	36	71	41	1
2001	**530**	169	81	133	7	7	28	91	14	0
2002	**530**	105	71	207	2	8	40	64	32	1
2003	**571**	126	71	237	1	4	25	64	42	1
Total by Gear	**10821**	1900	1021	3017	133	72	325	3158	1154	41
% of Total by Gear		**17.6%**	**9.4%**	**27.9%**	**1.2%**	**0.7%**	**3.0%**	**29.2%**	**10.7%**	**0.4%**

Table 2. A summary of the interviewed trips that landed spiny lobster by gear type.

Gear_Code	All Trips	Lobster Trips	% Lobster Trips By Gear
DIVE	1900	1530	80.5%
LOBTRAPS	72	47	65.3%
TRAPS	3158	590	18.7%
OTHER	41	6	14.6%
GILLNETS	1021	44	4.3%
SEINE	325	7	2.2%
HL	3017	37	1.2%
TROLL	1154	7	0.6%
LL	133	0	0.0%
Totals	**10821**	**2268**	**21.0%**

Table 3. A summary of the interviewed trips that landed spiny lobster by year and gear. The proportion represented by each gear is shown, highlighting the 3 gears that have a more significant contribution (Dive, Fish Traps, and Lobster Traps) to lobster landings.

Year	Lobster Trips	Dive	Fish Traps	Lobster Traps	Gillnets	Handlines	Seine	Troll	Other
1984	144	0	144	0	0	0	0	0	0
1985	66	1	65	0	0	0	0	0	0
1986	52	3	49	0	0	0	0	0	0
1987	82	20	58	4	0	0	0	0	0
1988	8	0	8	0	0	0	0	0	0
1989	126	79	32	0	3	8	0	0	4
1990	124	110	8	0	4	0	1	0	1
1991	181	130	31	7	5	8	0	0	0
1992	183	138	25	4	4	5	2	5	0
1993	146	118	16	4	2	6	0	0	0
1994	63	41	20	1	0	1	0	0	0
1995	133	119	13	0	0	0	0	1	0
1996	112	88	17	0	5	0	1	0	1
1997	61	45	13	3	0	0	0	0	0
1998	116	92	10	9	3	1	0	1	0
1999	151	114	25	5	4	3	0	0	0
2000	124	104	11	5	3	0	1	0	0
2001	157	136	13	5	2	0	1	0	0
2002	104	84	14	1	4	1	0	0	0
2003	135	108	17	0	5	4	1	0	0
Total	**2268**	1530	589	48	44	37	7	7	6
% of Total by Gear		**67.5%**	**26.0%**	**2.1%**	1.9%	1.6%	0.31%	0.31%	0.26%

Table 4. Species assemblage for spiny lobster and unidentified Panuliridae, Primary gear=FISH TRAPS, from the Puerto Rico TIP database. Only species with co-occurrence>95 trips and largest DH values were selected (shown highlighted).

NODC_CODE	SCI_NAME	COM_NAME	Lobstrips	Alltrips	Numerat	Denomin	DH_Stat
6182010101	PANULIRUS ARGUS	LOBSTER,SPINY	589	589	0.700	0.187	3.749
6182010000	PALINURIDAE	SPINY LOBSTERS, PALIN	253	253	0.300	0.080	3.749
8860030104	LACTOPHRYS QUADRICORNIS	COWFISH,SCRAWLED	115	400	0.137	0.127	1.078
8860030105	LACTOPHRYS POLYGONIA	HONEYCOMB COWFISH	95	391	0.113	0.124	0.911
8835430507	CALAMUS PENNATULA	PORGY,PLUMA	102	613	0.121	0.194	0.624
8860020202	BALISTES VETULA	TRIGGERFISH,QUEEN	133	850	0.158	0.269	0.587
8835020406	EPINEPHELUS GUTTATUS	HIND,RED	193	1300	0.229	0.412	0.557
8835360112	LUTJANUS SYNAGRIS	SNAPPER,LANE	160	1285	0.190	0.407	0.467
8835360401	OCYURUS CHRYSURUS	SNAPPER,YELLOWTAIL	146	1179	0.173	0.373	0.464
8835020438	EPINEPHELUS FULVUS	CONEY	146	1229	0.173	0.389	0.445
8835400102	HAEMULON PLUMIERI	GRUNT,WHITE	201	1701	0.239	0.539	0.443
8835450301	PSEUDUPENEUS MACULATUS	GOATFISH,SPOTTED	99	1037	0.118	0.328	0.358
8860030101	LACTOPHRYS TRIGONUS	TRUNKFISH	39	147	0.046	0.047	0.995
8860030103	LACTOPHRYS TRIQUETER	TRUNKFISH,SMOOTH	66	275	0.078	0.087	0.900
8860030102	LACTOPHRYS BICAUDALIS	TRUNKFISH,SPOTTED	80	340	0.095	0.108	0.882

Table 5. Species assemblage for spiny lobster and unidentified Panuliridae, Primary gear=DIVE, from the Puerto Rico TIP database. Only species with co-occurrence>30 trips and largest DH values were selected (shown highlighted).

NODC_CODE	SCI_NAME	COM_NAME	Lobstrips	Alltrips	Numerator	Denomin	DH_Stat
6182010101	PANULIRUS ARGUS	LOBSTER,SPINY	1530	1530	0.994	0.805	1.235
6182010000	PALINURIDAE	SPINY LOBSTERS, PALIN	8	8	0.005	0.004	1.235
8839010901	LACHNOLAIMUS MAXIMUS	HOGFISH	367	571	0.238	0.301	0.793
8835020406	EPINEPHELUS GUTTATUS	HIND,RED	263	419	0.171	0.221	0.775
8835020412	EPINEPHELUS STRIATUS	GROUPER,NASSAU	88	144	0.057	0.076	0.754
8835360109	LUTJANUS JOCU	SNAPPER,DOG	75	105	0.049	0.055	0.882
8835360104	LUTJANUS APODUS	SNAPPER,SCHOOLMASTER	71	120	0.046	0.063	0.730
6182020203	SCYLLARIDES AEQUINOCTIA.	LOBSTER,SPANISH SLIP.	47	47	0.031	0.025	1.235
8860020202	BALISTES VETULA	TRIGGERFISH,QUEEN	47	83	0.031	0.044	0.699
8835020402	EPINEPHELUS ADSCENSIONIS	HIND,ROCK	47	88	0.031	0.046	0.659
8835360103	LUTJANUS ANALIS	SNAPPER,MUTTON	45	75	0.029	0.039	0.741
8835020502	MYCTEROPERCA BONACI	GROUPER,BLACK	43	74	0.028	0.039	0.717
8839030406	SPARISOMA VIRIDE	PARROTFISH,STOPLIGHT	42	94	0.027	0.049	0.552
8860030105	LACTOPHRYS POLYGONIA	HONEYCOMB COWFISH	30	40	0.019	0.021	0.926
8835020439	EPINEPHELUS CRUENTATUS	GRAYSBY	17	25	0.011	0.013	0.840
8839030104	SCARUS GUACAMAIA	PARROTFISH,RAINBOW	16	29	0.010	0.015	0.681
8860030104	LACTOPHRYS QUADRICORNIS	COWFISH,SCRAWLED	15	20	0.010	0.011	0.926
8850030503	SCOMBEROMORUS REGALIS	MACKEREL,CERO	13	17	0.008	0.009	0.944
8860030102	LACTOPHRYS BICAUDALIS	TRUNKFISH,SPOTTED	13	20	0.008	0.011	0.802
8835020506	MYCTEROPERCA VENENOSA	GROUPER,YELLOWFIN	13	30	0.008	0.016	0.535
8835020438	EPINEPHELUS FULVUS	CONEY	13	32	0.008	0.017	0.502
8835360401	OCYURUS CHRYSURUS	SNAPPER,YELLOWTAIL	11	25	0.007	0.013	0.543
8839030403	SPARISOMA CHRYSOPTERUM	PARROTFISH,REDTAIL	10	28	0.006	0.015	0.441

Table 6. Species associated to spiny lobster with Primary gear=LOBSTER TRAPS, from the Puerto Rico TIP database. A species assemblage could not be determined due to small sample size (i.e., few fish trap trips). Only species with co-occurrence>1 trip are shown.

NODC_CODE	SCI_NAME	COM_NAME	lobstrips	alltrips	numerator	denominat	DH_Stat
6182010101	PANULIRUS ARGUS	LOBSTER,SPINY	48	48	1	0.667	1.5
8835020439	EPINEPHELUS CRUENTATUS	GRAYSBY	2	2	0.042	0.028	1.5
8835280306	CARANX CRYSOS	BLUE RUNNER	2	2	0.042	0.028	1.5
8835280803	SERIOLA RIVOLIANA	ALMACO JACK	2	2	0.042	0.028	1.5
8835360501	RHOMBOPLITES AURORUBENS	SNAPPER,VERMILION	2	2	0.042	0.028	1.5
8860030101	LACTOPHRYS TRIGONUS	TRUNKFISH	2	2	0.042	0.028	1.5
8860030104	LACTOPHRYS QUADRICORNIS	COWFISH,SCRAWLED	5	7	0.104	0.097	1.071
8839010901	LACHNOLAIMUS MAXIMUS	HOGFISH	2	3	0.042	0.042	1
8860030102	LACTOPHRYS BICAUDALIS	TRUNKFISH,SPOTTED	4	8	0.083	0.111	0.750
8860030105	LACTOPHRYS POLYGONIA	HONEYCOMB COWFISH	2	4	0.042	0.056	0.750
8835360110	LUTJANUS MAHOGONI	SNAPPER,MAHOGONY	2	5	0.042	0.069	0.600
8839030406	SPARISOMA VIRIDE	PARROTFISH,STOPLIGHT	2	5	0.042	0.069	0.600
8860030103	LACTOPHRYS TRIQUETER	TRUNKFISH,SMOOTH	2	5	0.042	0.069	0.600
8835280308	CARANX RUBER	BAR JACK	2	6	0.042	0.083	0.500
8835020406	EPINEPHELUS GUTTATUS	HIND,RED	5	16	0.104	0.222	0.469
8835430507	CALAMUS PENNATULA	PORGY,PLUMA	2	7	0.042	0.097	0.429
8835450301	PSEUDUPENEUS MACULATUS	GOATFISH,SPOTTED	2	7	0.042	0.097	0.429
8839030403	SPARISOMA CHRYSOPTERUM	PARROTFISH,REDTAIL	3	12	0.063	0.167	0.375
8835400102	HAEMULON PLUMIERI	GRUNT,WHITE	4	17	0.083	0.236	0.353
8835360401	OCYURUS CHRYSURUS	SNAPPER,YELLOWTAIL	3	13	0.063	0.181	0.346
8835430000	SPARIDAE	SCUPS OR PORGIES,JUMB	2	9	0.042	0.125	0.333
8835360112	LUTJANUS SYNAGRIS	SNAPPER,LANE	3	14	0.063	0.194	0.321
8835020438	EPINEPHELUS FULVUS	CONEY	2	12	0.042	0.167	0.250

Table 7. Proportion of observations by Effort Unit.

	GEAR_CODE= DIVE			
	GEARNUM (Num Dives)	GEARQTY (Num Divers)	SOAK (Hrs Fished)	STDEPTH
Total Obs	1530	1530	1530	1530
0 or Missing'	795	877	739	523
N Obs	735	653	791	1007
% non 0 obs	48%	43%	52%	66%
	GEAR_CODE= LOBTRAPS			
	GEARNUM (Traps Set)	GEARQTY (Traps Hauled)	SOAK (Hrs Set to Haul)	STDEPTH
Total Obs	47	47	47	47
0 or Missing'	22	23	5	11
N Obs	25	24	42	36
% non 0 obs	53%	51%	89%	77%
	GEAR_CODE= TRAPS			
	GEARNUM (Traps Set)	GEARQTY (Traps Hauled)	SOAK (Hrs Set to Haul)	STDEPTH
Total Obs	589	589	589	589
0 or Missing'	471	463	385	391
N Obs	118	126	204	198
% non 0 obs	20%	21%	35%	34%

Table 8. Statistics of effort information (GEARNUM= Number of gear; GEARQTY= gear quantity; SOAK= hours fished, and AVGDEPTH= mean depth) by gear type (Dive, Lobster Traps,and Fish Traps).

GEARNUM			
GEAR_CODE	DIVE (Num Dives)	LOBTRAPS (Set)	TRAPS (Set)
Mean	2.48	23.92	30.58
Std Dev	2.51	11.93	29.57
Std Err Mean	0.09	2.39	2.72
upper 95% Mean	2.66	28.85	35.97
lower 95% Mean	2.30	18.99	25.19
Range	1-31	1-41	1-200
N	734	25	118
GEARQTY			
GEAR_CODE	DIVE (Num Divers)	LOBTRAPS (Hauled)	TRAPS (Hauled)
Mean	2.09	23.08	36.38
Std Dev	1.60	17.18	31.08
Std Err Mean	0.06	3.51	2.77
upper 95% Mean	2.22	30.34	41.86
lower 95% Mean	1.97	15.83	30.90
Range	1-8	1-91	1-150
N	653	24	126
SOAK			
GEAR_CODE	DIVE (Hrs Fished)	LOBTRAPS (Hrs Set to Haul)	TRAPS (Hrs Set to Haul)
Mean	4.41	29.85	29.62
Std Dev	1.28	47.54	46.11
Std Err Mean	0.05	7.34	3.23
upper 95% Mean	4.50	44.66	35.99
lower 95% Mean	4.32	15.03	23.26
Range	1-13	3-192	2-336
N	790	42	204
AVGDEPTH (Fathoms)			
GEAR_CODE	DIVE	LOBTRAPS	TRAPS
Mean	10.64	21.26	25.40
Std Dev	11.84	9.98	13.17
Std Err Mean	0.37	1.66	0.94
upper 95% Mean	11.38	24.64	27.24
lower 95% Mean	9.91	17.89	23.55
Range	1-92	5-45	4.5-100
N	1006	36	198

Table 9. Deviance analysis tables for the selection of explanatory variables in the **Binomial mode**l for the **Puerto Rico combined fishery**. Factors were added to the model if PROBCHISQ<0.05 and % REDUCTION in DEV/DF≥1.0%. Only the first and last steps in the stepwise process are show, with the final model in bold font.

SUCCESS (Binomial Model)

There are no explanatory factors in the base model.

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	4141	5741.4	1.3865		-2870.7		
SEASON2	4138	5727.1	1.3840	0.18	-2863.6	14.24	0.00260
COAST2	4139	5644.7	1.3638	1.64	-2822.3	96.68	0.00000
YEAR2	4122	4761.6	1.1552	16.68	-2380.8	979.82	0.00000
GEAR2	4140	4343.3	1.0491	24.33	-2171.7	1398.04	0.00000

The explanatory factors in the base model are: GEAR2

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	4140	4343.3	1.0491		-2171.7		
SEASON2	4137	4326.8	1.0459	0.31	-2163.4	16.54	0.00088
COAST2	4138	4312.4	1.0422	0.66	-2156.2	30.91	0.00000
YEAR2	4121	4102.9	0.9956	5.10	-2051.5	240.41	0.00000

The explanatory factors in the base model are: YEAR2 GEAR2

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	4121	4102.9	0.9956		-2051.5		
SEASON2	4118	4088.2	0.9928	0.29	-2044.1	14.76	0.00204
COAST2	4119	4064.0	0.9867	0.90	-2032.0	38.88	0.00000

The explanatory factors in the base model are: **YEAR2 GEAR2 YEAR2*GEAR2**

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	4121	4102.9	0.9956		-2051.5		
SEASON2	4118	4088.2	0.9928	0.29	-2044.1	14.76	0.00204
SEASON2 * GEAR2	4115	4075.2	0.9903	0.53	-2037.6	.	.
COAST2	4119	4064.0	0.9867	0.90	-2032.0	38.88	0.00000
SEASON2 * COAST2	4110	4029.7	0.9805	1.52	-2014.8	.	.
YEAR2 * GEAR2	4102	3963.1	0.9662	2.96	-1981.6	.	.
COAST2 * GEAR2	4117	3955.1	0.9607	3.51	-1977.5	.	.
YEAR2*SEASON2	4061	3940.0	0.9702	2.55	-1970.0	.	.
YEAR2* COAST2	4081	3901.9	0.9561	3.97	-1951.0	.	.

Table 10. Deviance analysis tables for the selection of explanatory variables in the **Lognormal model** for the **Puerto Rico combined fishery.** Factors were added to the model if PROBCHISQ<0.05 and % REDUCTION in DEV/DF≥1.0%. The stepwise selection of factors and interactions is shown, with the final model in bold font.

Positive (Lognormal Model)

There are no explanatory factors in the base model.

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	2044	1198.8	0.5865		-2355.6		
YEAR2	2026	1140.5	0.5629	4.02	-2304.6	101.96	0.00000
COAST2	2042	1157.4	0.5668	3.36	-2319.7	71.85	0.00000
GEAR2	2043	1196.3	0.5855	0.16	-2353.5	4.30	0.03811
SEASON2	2041	1198.2	0.5871	-0.10	-2355.2	0.95	0.81390

The explanatory factors in the base model are: YEAR2

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	2026	1140.5	0.5629		-2304.6		
COAST2	2024	1113.3	0.5501	2.28	-2280.0	49.24	0.00000
SEASON2	2023	1138.4	0.5627	0.03	-2302.8	3.67	0.29974
GEAR2	2025	1140.5	0.5632	-0.05	-2304.6	0.02	0.88908

The explanatory factors in the base model are: YEAR2 COAST2

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	2024	1113.3	0.5501		-2280.0		
GEAR2	2023	1106.6	0.5470	0.55	-2273.8	12.37	0.00044
SEASON2	2021	1111.5	0.5500	0.02	-2278.3	3.38	0.33703

The explanatory factors in the base model are: YEAR2 COAST2

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	2023	1112.4	0.5499		-2279.1		
YEAR2* COAST2	1988	1001.5	0.5038	8.38	-2171.8	.	.
COAST2 * GEAR2	2020	1065.3	0.5274	4.09	-2234.9	.	.
YEAR2 * GEAR2	2005	1077.4	0.5373	2.28	-2246.4	.	.
YEAR2*SEASON2	1966	1067.1	0.5428	1.29	-2236.6	85.00	0.00950
SEASON2 * GEAR2	2016	1100.3	0.5458	0.75	-2267.9	.	.
GEAR2	2022	1105.7	0.5468	0.55	-2272.9	12.38	0.00043
SEASON2 * COAST2	2014	1104.1	0.5482	0.30	-2271.5	.	.
SEASON2	2020	1110.4	0.5497	0.03	-2277.3	3.72	0.29390

Table 10 (cont.)

The explanatory factors in the base model are: **YEAR2 COAST2 YEAR2*COAST2**

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	1988	1001.5	0.5038		-2171.8		
YEAR2 * GEAR2	1970	974.6	0.4947	1.80	-2143.9	.	.
COAST2 * GEAR2	1985	987.9	0.4977	1.21	-2157.8	.	.
YEAR2*SEASON2	1931	964.5	0.4995	0.85	-2133.3	76.94	0.04036
SEASON2 * GEAR2	1981	994.4	0.5020	0.36	-2164.5	.	.
GEAR2	1987	997.9	0.5022	0.31	-2168.1	7.40	0.00653
SEASON2	1985	1000.4	0.5040	-0.04	-2170.6	2.24	0.52453
SEASON2 * COAST2	1979	998.2	0.5044	-0.12	-2168.4	.	.

Table 11. Puerto Rico-All gears combined (FISH TRAPS + LOBSTER TRAPS + DIVE)**- Delta-Lognormal Model.** Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for spiny lobster, years 1984-2003.

					Scaled Index		
Year	Nominal	Estimated	Coeff Var	Obscpue	StdIndex	95% confidence interv	
1984	2.758	5.361	30.3%	0.355	0.679	0.375	1.229
1985	4.282	8.267	31.3%	0.551	1.047	0.568	1.930
1986	4.187	8.770	36.5%	0.538	1.111	0.548	2.253
1987	5.067	7.035	30.6%	0.651	0.891	0.490	1.621
1988	0.621	0.489	123.3%	0.080	0.062	0.009	0.424
1989	6.108	5.388	31.2%	0.785	0.683	0.371	1.256
1990	7.030	5.546	32.2%	0.904	0.703	0.375	1.316
1991	9.461	8.949	27.5%	1.216	1.134	0.660	1.946
1992	8.184	7.101	25.4%	1.052	0.900	0.546	1.482
1993	8.701	8.108	25.7%	1.119	1.027	0.620	1.703
1994	7.664	7.973	27.8%	0.985	1.010	0.585	1.743
1995	9.728	9.205	27.4%	1.251	1.166	0.681	1.997
1996	10.272	10.076	27.9%	1.321	1.276	0.738	2.208
1997	6.864	6.701	32.6%	0.883	0.849	0.449	1.604
1998	9.577	8.571	29.2%	1.231	1.086	0.613	1.923
1999	12.071	11.301	26.2%	1.552	1.432	0.855	2.397
2000	10.330	9.499	28.5%	1.328	1.203	0.688	2.106
2001	13.154	10.879	26.8%	1.691	1.378	0.814	2.332
2002	8.735	7.956	30.1%	1.123	1.008	0.559	1.817
2003	10.748	10.691	27.8%	1.382	1.354	0.784	2.338

Table 12. Puerto Rico-All gears combined (FISH TRAPS + LOBSTER TRAPS + DIVE)- GLM Model. Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for spiny lobster, years 1984-2003.

					Scaled Index		
Year	Nominal	Estimated	Coeff Var	Obscpue	StdIndex	95% confidence intervals	
1984	15.897	13.465	20.0%	1.064	1.040	1.546	0.699
1985	18.398	16.480	20.9%	1.232	1.268	1.919	0.838
1986	27.470	23.829	20.5%	1.839	1.831	2.747	1.221
1987	17.090	13.137	20.3%	1.144	1.014	1.516	0.679
1988	12.627	9.014	42.1%	0.845	0.654	1.466	0.291
1989	13.225	10.061	22.2%	0.885	0.776	1.204	0.500
1990	11.796	9.752	23.8%	0.790	0.750	1.199	0.469
1991	15.409	12.486	23.3%	1.032	0.959	1.517	0.606
1992	13.292	10.418	20.0%	0.890	0.807	1.199	0.543
1993	12.610	10.779	20.1%	0.844	0.834	1.243	0.560
1994	10.346	9.261	21.6%	0.693	0.716	1.097	0.468
1995	12.944	12.213	19.9%	0.867	0.945	1.401	0.637
1996	13.599	13.095	20.0%	0.910	1.012	1.504	0.681
1997	10.015	9.066	22.7%	0.671	0.700	1.095	0.447
1998	14.058	12.875	19.5%	0.941	0.996	1.466	0.677
1999	17.389	15.882	19.1%	1.164	1.227	1.791	0.841
2000	15.279	14.394	19.4%	1.023	1.113	1.633	0.758
2001	18.876	16.322	18.9%	1.264	1.261	1.836	0.866
2002	13.637	12.547	19.9%	0.913	0.970	1.439	0.654
2003	14.778	14.587	19.6%	0.989	1.127	1.662	0.764

Table 13. Puerto Rico- DIVE gear- Delta-Lognormal Model Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for spiny lobster, years 1989-2003.

					Scaled Index		
Year	Nominal	Estimated	Coeff Var	Obscpue	StdIndex	95% confidence interv	
1989	9.101	7.924	21.7%	0.803	0.743	0.483	1.141
1990	10.147	10.269	19.4%	0.895	0.962	0.655	1.413
1991	14.062	11.959	20.1%	1.240	1.121	0.753	1.668
1992	12.214	11.721	17.1%	1.077	1.098	0.783	1.541
1993	11.772	11.833	16.8%	1.038	1.109	0.795	1.547
1994	9.958	8.974	19.7%	0.878	0.841	0.569	1.243
1995	11.663	13.080	16.5%	1.029	1.226	0.884	1.700
1996	11.091	9.733	17.2%	0.978	0.912	0.648	1.283
1997	7.881	9.547	22.5%	0.695	0.895	0.574	1.395
1998	9.792	8.465	17.0%	0.864	0.793	0.566	1.113
1999	13.670	12.183	16.2%	1.206	1.142	0.828	1.574
2000	12.409	11.216	16.4%	1.094	1.051	0.759	1.455
2001	15.746	13.346	15.4%	1.389	1.251	0.922	1.697
2002	9.064	8.606	18.0%	0.799	0.806	0.565	1.152
2003	11.521	11.218	17.2%	1.016	1.051	0.748	1.478

Table 14. Puerto Rico- DIVE gear- Delta-Lognormal Model- Depth method. Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for spiny lobster, years 1990-2003.

					Scaled Index		
Year	Nominal	Estimated	Coeff Var	Obscpue	StdIndex	95% confidence interv	
1990	10.189	10.162	22.7%	0.879	0.942	0.602	1.473
1991	14.309	12.829	21.9%	1.235	1.189	0.771	1.833
1992	12.043	11.293	18.6%	1.039	1.046	0.723	1.514
1993	11.785	11.062	18.5%	1.017	1.025	0.710	1.479
1994	10.963	8.882	24.1%	0.946	0.823	0.512	1.324
1995	12.496	13.425	18.5%	1.078	1.244	0.862	1.795
1996							
1997	8.293	10.004	26.7%	0.716	0.927	0.548	1.567
1998	10.080	8.998	19.6%	0.870	0.834	0.565	1.230
1999	13.602	11.670	19.5%	1.174	1.081	0.734	1.592
2000	12.736	10.577	18.6%	1.099	0.980	0.677	1.418
2001	14.126	12.613	17.6%	1.219	1.169	0.824	1.657
2002	8.608	7.734	20.5%	0.743	0.717	0.477	1.076
2003	11.421	11.055	18.6%	0.986	1.024	0.709	1.480

Table 15. Puerto Rico- FISH TRAPS- Delta-Lognormal Model. Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for spiny lobster, years 1989-2003.

					Scaled Index		
Year	Nominal	Estimated	Coeff Var	Obscpue	StdIndex	95% confidence interv	
1984	2.869	3.030	17.1%	0.688	0.615	0.438	0.862
1985	4.366	4.415	19.9%	1.047	0.896	0.604	1.328
1986	4.134	5.679	22.9%	0.991	1.152	0.733	1.811
1987	4.116	5.104	21.9%	0.987	1.035	0.672	1.595
1988	0.881	0.865	65.4%	0.211	0.175	0.053	0.579
1989	3.631	4.642	26.4%	0.871	0.942	0.560	1.583
1990	0.935	1.057	54.1%	0.224	0.214	0.078	0.591
1991	4.071	4.193	27.0%	0.976	0.850	0.500	1.446
1992	2.519	3.019	28.5%	0.604	0.612	0.351	1.070
1993	2.239	2.884	36.0%	0.537	0.585	0.291	1.175
1994	4.515	6.027	28.3%	1.083	1.223	0.702	2.131
1995	3.244	4.016	41.5%	0.778	0.815	0.367	1.806
1996	7.745	9.991	30.1%	1.857	2.027	1.125	3.652
1997	3.786	4.304	37.4%	0.908	0.873	0.423	1.801
1998	4.212	4.761	49.3%	1.010	0.966	0.380	2.454
1999	7.612	7.420	27.5%	1.825	1.505	0.878	2.581
2000	2.744	3.070	44.4%	0.658	0.623	0.267	1.455
2001	2.989	3.908	39.9%	0.717	0.793	0.368	1.709
2002	7.294	8.120	36.5%	1.749	1.647	0.812	3.340
2003	9.494	12.092	31.8%	2.277	2.453	1.318	4.567

Table 16. Puerto Rico- LOBSTER TRAPS-GLM Model. Nominal CPUE, estimated CPUE, coefficient of variation, and scaled relative abundance index for spiny lobster, years 1991-2001.

					Scaled Index		
Year	Nominal	Estimated	Coeff Var	Obscpue	StdIndex	95% confidence interv	
1991	16.528	16.614	30.8%	0.867	0.944	1.725	0.517
1992	17.353	18.788	36.4%	0.911	1.047	2.119	0.517
1993	25.061	14.781	44.2%	1.315	0.800	1.861	0.344
1994	14.626	11.662	60.7%	0.768	0.581	1.780	0.190
1995							
1996							
1997	18.680	24.148	44.5%	0.980	1.298	3.040	0.554
1998	26.439	25.323	28.5%	1.387	1.446	2.530	0.826
1999	18.680	20.872	33.5%	0.980	1.174	2.254	0.612
2000	20.432	18.661	33.9%	1.072	1.049	2.028	0.543
2001	13.705	11.817	36.5%	0.719	0.661	1.342	0.326

Table 17. A summary of the standardized Delta-Lognormal indices (in lb/trip) estimated for the overall combined fishery, and the dive and fish trap fisheries.

Year	Overall	Dive	Dive-Depth	Fish Traps
1984	5.36			3.03
1985	8.27			4.42
1986	8.77			5.68
1987	7.04			5.10
1988	0.49			0.86
1989	5.39	7.92		4.64
1990	5.55	10.27	10.16	1.06
1991	8.95	11.96	12.83	4.19
1992	7.10	11.72	11.29	3.02
1993	8.11	11.83	11.06	2.88
1994	7.97	8.97	8.88	6.03
1995	9.21	13.08	13.43	4.02
1996	10.08	9.73		9.99
1997	6.70	9.55	10.00	4.30
1998	8.57	8.46	9.00	4.76
1999	11.30	12.18	11.67	7.42
2000	9.50	11.22	10.58	3.07
2001	10.88	13.35	12.61	3.91
2002	7.96	8.61	7.73	8.12
2003	10.69	11.22	11.05	12.09

Table 18. A summary of the SCALED standard Delta-Lognormal indices estimated for the overall, dive, and fish trap fisheries and for the GLM lobster trap fishery.

Year	Overall	Dive	Dive-Depth	Fish Traps	GLM LobsTraps
1984	0.68			0.61	
1985	1.05			0.90	
1986	1.11			1.15	
1987	0.89			1.04	
1988	0.06			0.18	
1989	0.68	0.74		0.94	
1990	0.70	0.96	0.94	0.21	
1991	1.13	1.12	1.19	0.85	0.94
1992	0.90	1.10	1.05	0.61	1.05
1993	1.03	1.11	1.02	0.58	0.80
1994	1.01	0.84	0.82	1.22	0.58
1995	1.17	1.23	1.24	0.81	
1996	1.28	0.91		2.03	
1997	0.85	0.89	0.93	0.87	1.30
1998	1.09	0.79	0.83	0.97	1.45
1999	1.43	1.14	1.08	1.51	1.17
2000	1.20	1.05	0.98	0.62	1.05
2001	1.38	1.25	1.17	0.79	0.66
2002	1.01	0.81	0.72	1.65	
2003	1.35	1.05	1.02	2.45	

Figure 1. A summary of the interviewed trips that landed spiny lobster by gear type from the Puerto Rico TIP database (1980-2003).

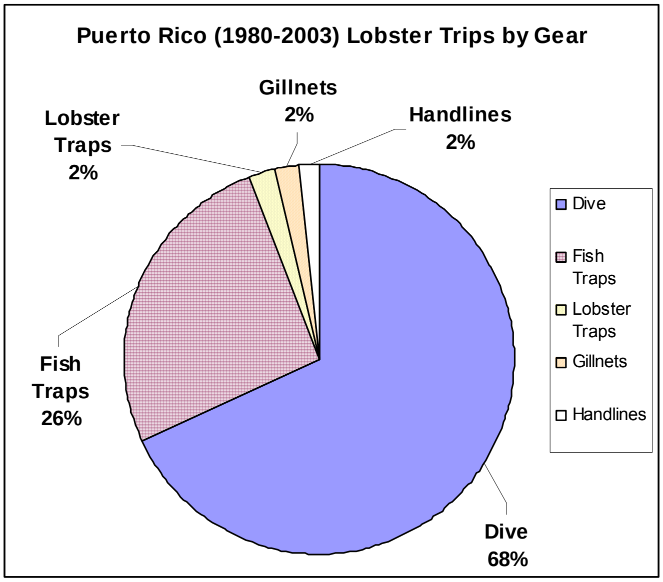
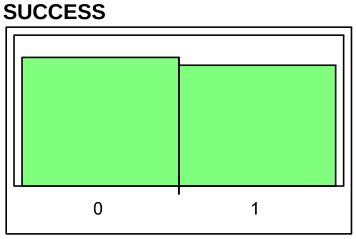


Figure 2. Diagnostic plots of categorical variables for all the lobster gears combined (all trips, positive and zero trips).

DISTRIBUTIONS ALL TRIPS

SUCCESS



Frequencies

Level	Count	Prob
0	2304	0.51544
1	2166	0.48456
Total	4470	1.00000

YEAR

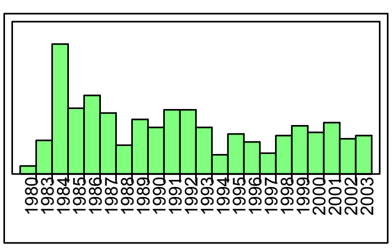
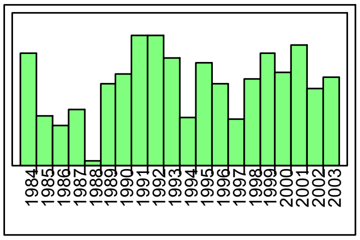


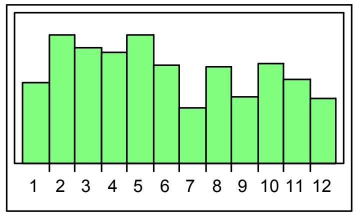
Figure 2 (Cont.).

DISTRIBUTION POSITIVE LOBSTER TRIPS

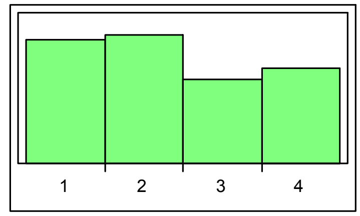
YEAR



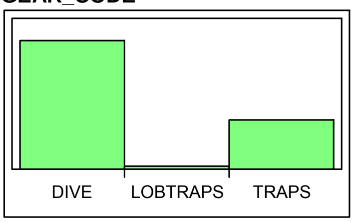
MONTH



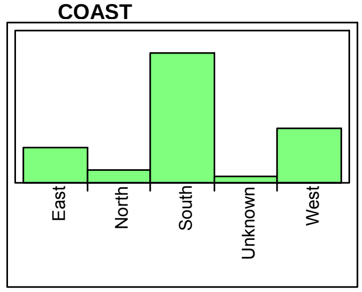
SEASON



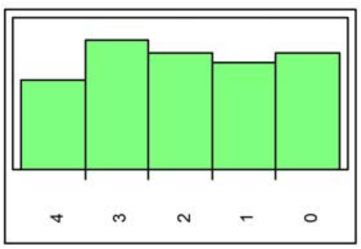
GEAR_CODE



COAST



DEPTH OF LOBSTER DIVE TRIPS



Level (Fathoms)	Count	Prob
0= Unknown	305	0.20720
1= 0 - 6	283	0.19226
2= 6 - 7.25	307	0.20856
3= 7.25 -12.5	341	0.23166
4= > 12.5	236	0.16033
Total	1472	1.00000

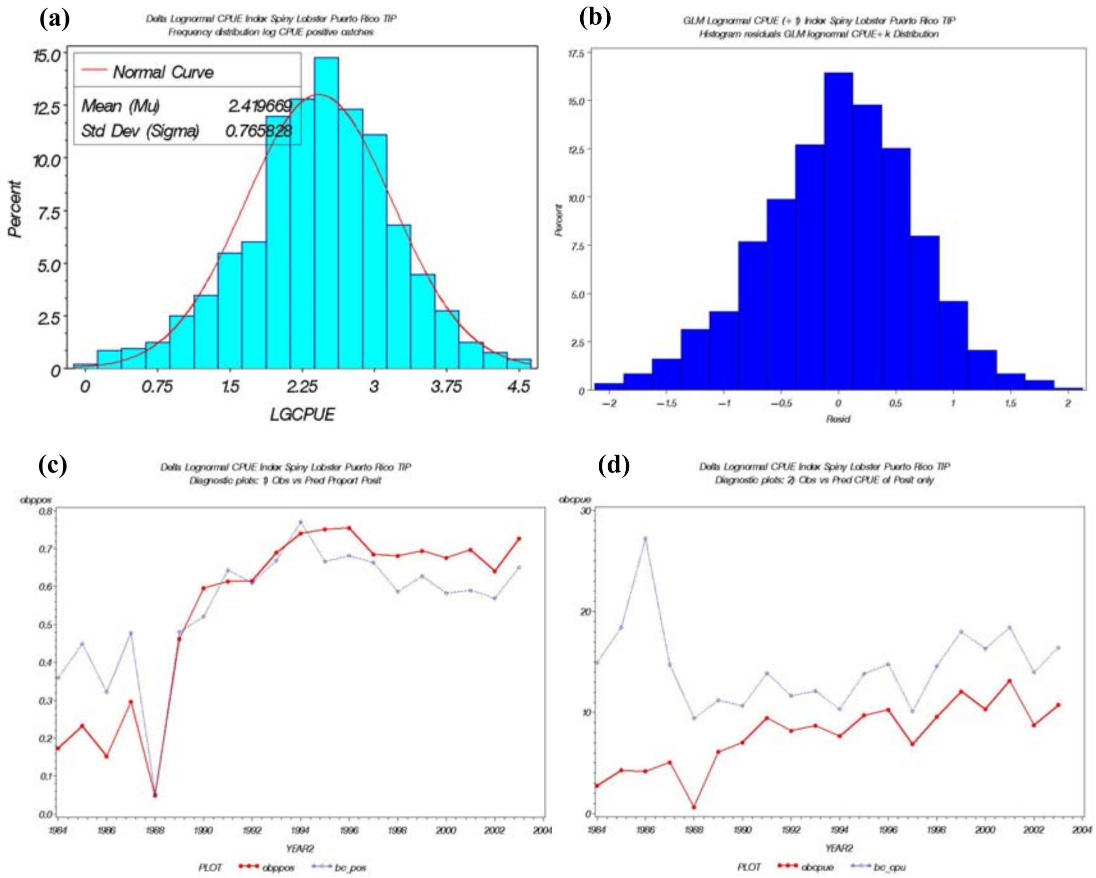


Figure 3. Puerto Rico-All gears combined (FISH TRAPS + LOBSTER TRAPS + DIVE). Diagnostic plots from fitting a **Delta-Lognormal** model to spiny lobster data from TIP. The plots shown are: (a) the distribution of the log(CPUE), (b) the distribution of residuals for the positive model, (c) observed and predicted proportion of positive trips and (d) observed and predicted CPUEs. The model includes years 1984-2003.

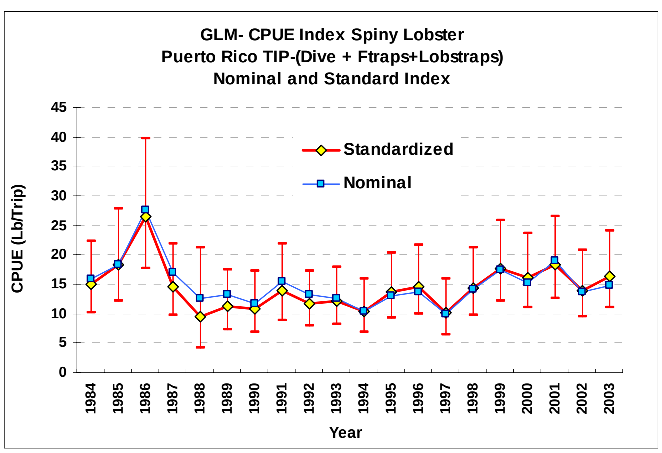


Figure 4 . Puerto Rico-All gears combined (FISH TRAPS + LOBSTER TRAPS + DIVE)- Nominal CPUE, standardized index of abundance and 95% confidence limits for spiny lobster, years 1984-2003.

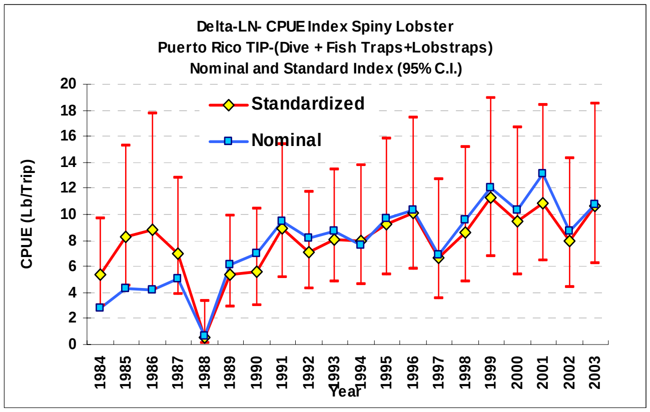


Figure 5 . Puerto Rico-All gears combined (FISH TRAPS + LOBSTER TRAPS + DIVE)- **GLM Model.** Nominal CPUE, standardized index of abundance and 95% confidence limits for spiny lobster, years 1984-2003.

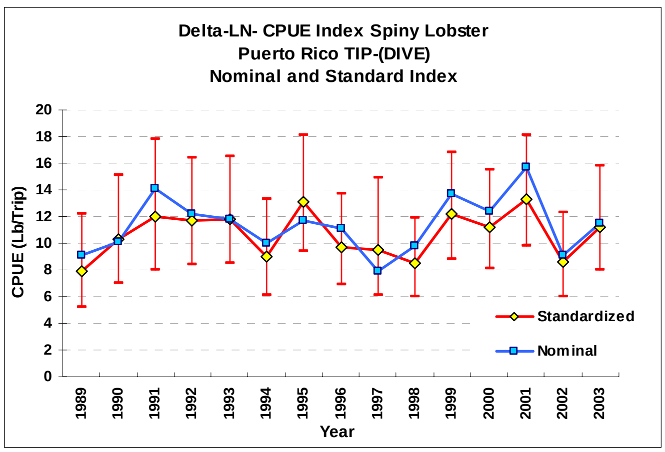


Figure 6. Puerto Rico-DIVE. Nominal CPUE, standardized index of abundance and 95% confidence limits for spiny lobster, years 1989-2003.

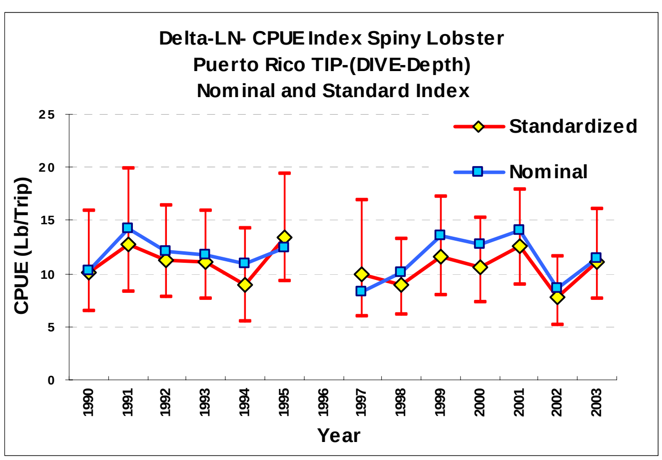


Figure 7. Puerto Rico-DIVE - DEPTH Method. Nominal CPUE, standardized index of abundance and 95% confidence limits for spiny lobster, years 1989-2003.

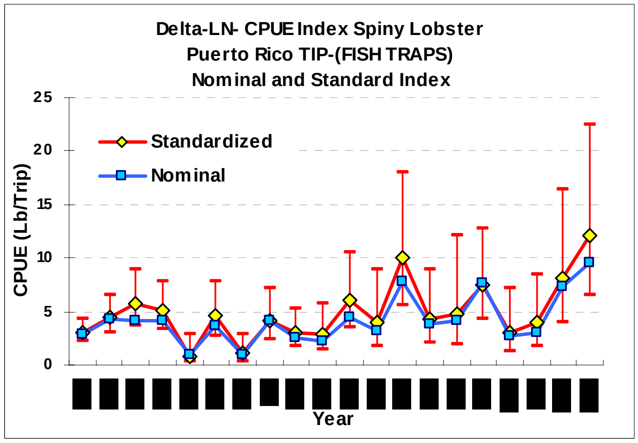


Figure 8. Puerto Rico-FISH TRAPS- Nominal CPUE, standardized index of abundance and 95% confidence limits for spiny lobster, years 1984-2003.

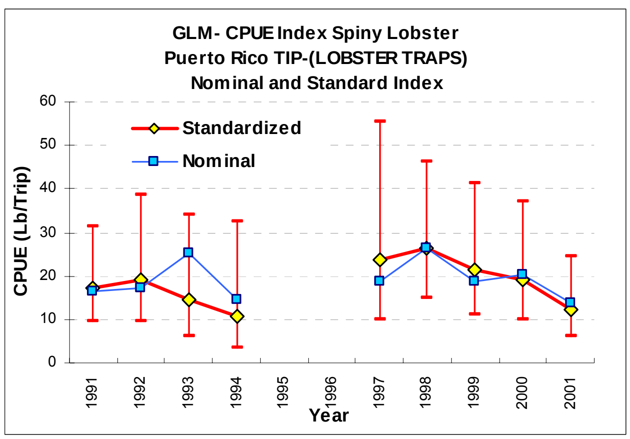


Figure 9. Puerto Rico-LOBSTER TRAPS- GLM Model. Nominal CPUE, standardized index of abundance and 95% confidence limits for spiny lobster, years 1991-2001.

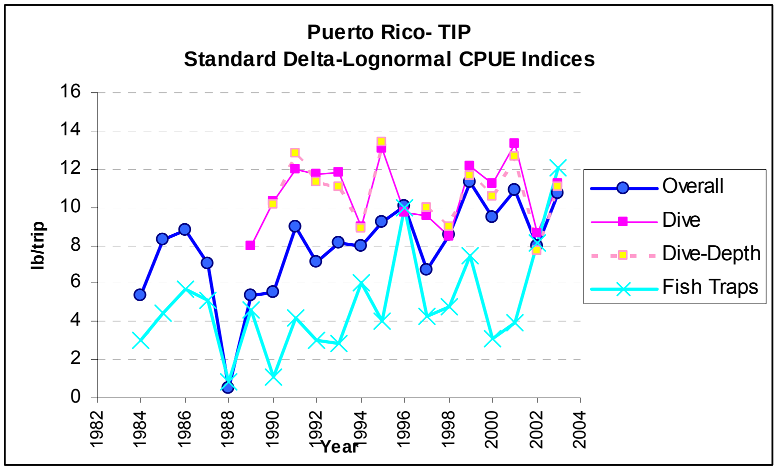


Figure 10. A summary of the standardized Delta-Lognormal indices (in lb/trip) estimated for the overall combined fishery, and the dive and fish trap fisheries.

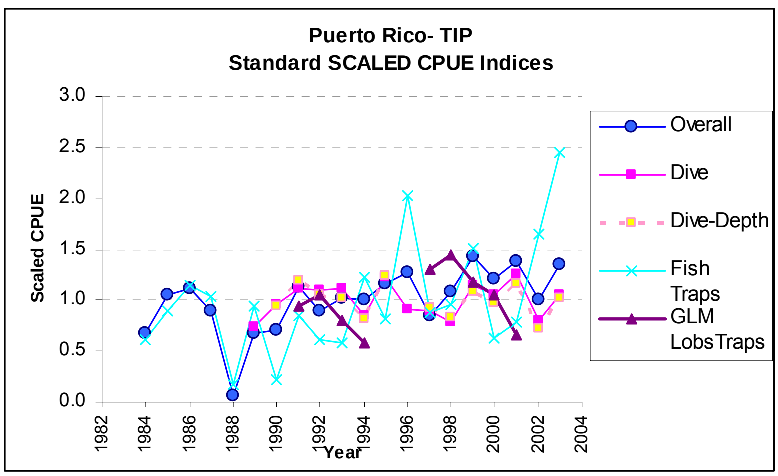


Figure 11. A summary of the SCALED standard Delta-Lognormal indices estimated for the overall, dive, and fish trap fisheries and for the GLM lobster trap fishery.