Delta-lognormal and multinomial approaches to index development for parrotfish, silk snapper, and queen snapper from Puerto Rican Trip Tickets

G. Walter Ingram

SEDAR26-DW-07

Date Submitted: 22 July 2011

Delta-lognormal and multinomial approaches to index development for parrotfish, silk snapper, and queen snapper from Puerto Rican Trip Tickets

Walter Ingram
NOAA Fisheries, Southeast Fisheries Science Center
Mississippi Laboratories, Pascagoula, MS

Abundance indices were developed for parrotfish, silk snapper, and queen snapper harvested by divers, fishpots, handlines, and gill and trammel nets and reported by trip tickets in Puerto Rico using the following multinomial approach. The multinomial index of relative abundance ($I_{s,y}$) was estimated as

$$\boldsymbol{I_{s,y} = c_y p_{s,y},}$$

where c_y is the estimate of mean total catch rate (lbs per station i.d.) for year y; $p_{s,y}$ is the estimate of the mean proportion of the catch made up by species s during year y.

Both c_y and $p_{s,y}$ were estimated using generalized linear models. Data used to estimate mean total catch rates (c) and species-specific mean proportion of the catch (p_s) were assumed to have a lognormal distribution and a multinomial distribution, respectively, and modeled using the following equations:

$$\ln(\mathbf{c}) = \mathbf{X\beta} + \boldsymbol{\varepsilon} \qquad \text{and} \qquad \ln\left(\frac{\mathbf{p}_s}{\mathbf{p}_5}\right) = \mathbf{X\beta} + \boldsymbol{\varepsilon}$$

respectively, where **c** is a vector of the catch rate data, $\mathbf{p}_s$ is a vector of data of the proportion of catch this is made up by species s, **X** is the design matrix for main effects, **β** is the parameter vector for main effects, and **ε** is a vector of independent normally distributed errors with expectation zero and variance σ^2. For the multinomial model, there were five catch proportion categories: four for each species in the silk group (blackfin, silk, black and vermilion snapper) and one for all other species combined (i.e. the rest of the catch). Since the "rest of catch" category comprised the largest proportion of the catch on average, this category (p_5) was treated as the baseline category; the four logit equations then described the log-odds of the rest of the catch being made up of each of the four species in the silk group.

c_y and $p_{s,y}$ were estimated as least-squares means for each year along with their corresponding standard errors, SE(c_y) and SE($p_{s,y}$), respectively. From these estimates, $I_{s,y}$ was calculated and its variance calculated as:

$$V(I_{s,y}) \approx V(c_y)p_{s,y}^2 + c_y^2 V(p_{s,y}) + 2c_y p_{s,y}\mathrm{Cov}(c, p_s)$$

where

$$\mathrm{Cov}(c, p_s) \approx \rho_{c,p}\left[\mathrm{SE}(c_y)\mathrm{SE}(p_{s,y})\right]$$

and $\rho_{c,p}$ denotes correlation of c and p_s among years. A table of variables used in each model and the unit of effort is listed with the index output of each species and gear combination.

Also, delta-lognormal models were developed as described by Lo *et al.* (1992) for parrotfish, and a table of variables used in each model and the unit of effort is listed with the index output of each species and gear combination.

Initial model runs were developed for the data workshop, and the results herein represent the new model runs that the index group and the workshop as a whole agreed upon. For parrotfish and the other species the delta-lognormal approach is recommended, since the multinomial approach has not yet been through peer-review and published. Therefore, index values were only reported for the delta-lognormal runs for parrotfish with each relevant gear.

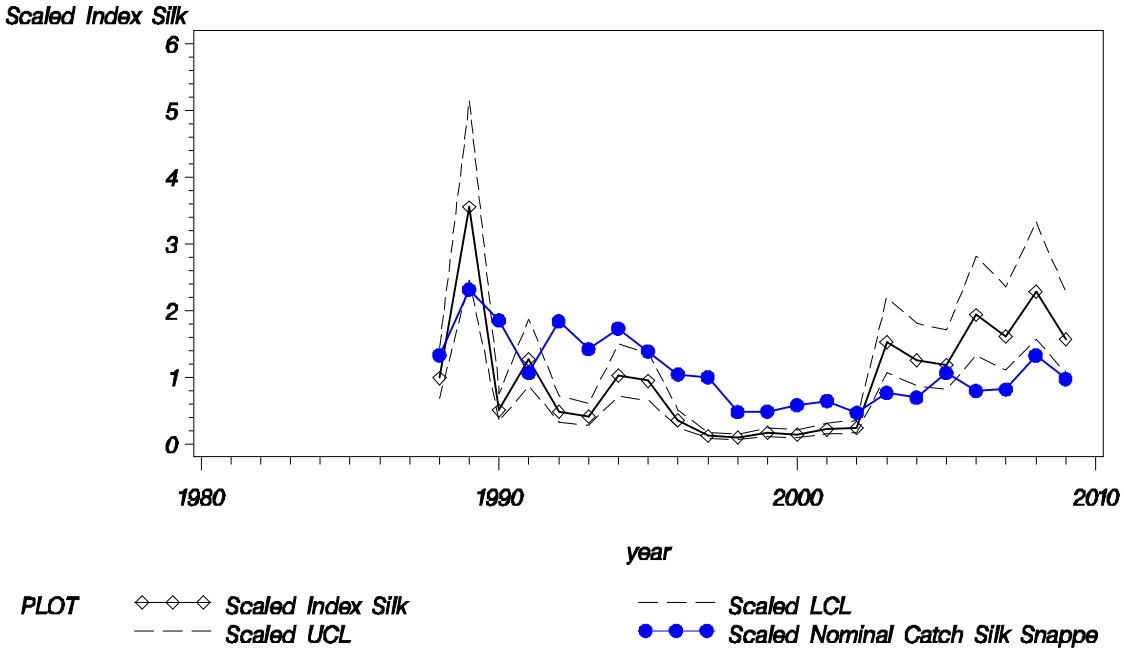
Lo, N. C. H., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-1526.

Silk Group Handlines Multinomial – Effort: hook-hours

Model Variables

Class	*Levels*	*Values*
yr	22	1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
quarter	4	1 2 3 4
month	12	1 2 3 4 5 6 7 8 9 10 11 12
coast	4	EAST NORTH SOUTH WEST
FISHING_CENTER	70	010 011 030 050 060 061 120 121 130 131 132 150 151 152 153 160 161 180 181 182 183 200 201 210 211 212 220 221 250 251 280 281 282 290 291 292 320 321 330 350 351 352 353 360 361 362 370 371 372 373 374 375 376 377 380 381 382 383 384 390 400 401 402 403 410 411 420 421 422 423
PR_GEAR_CODE	4	104 105 112 113

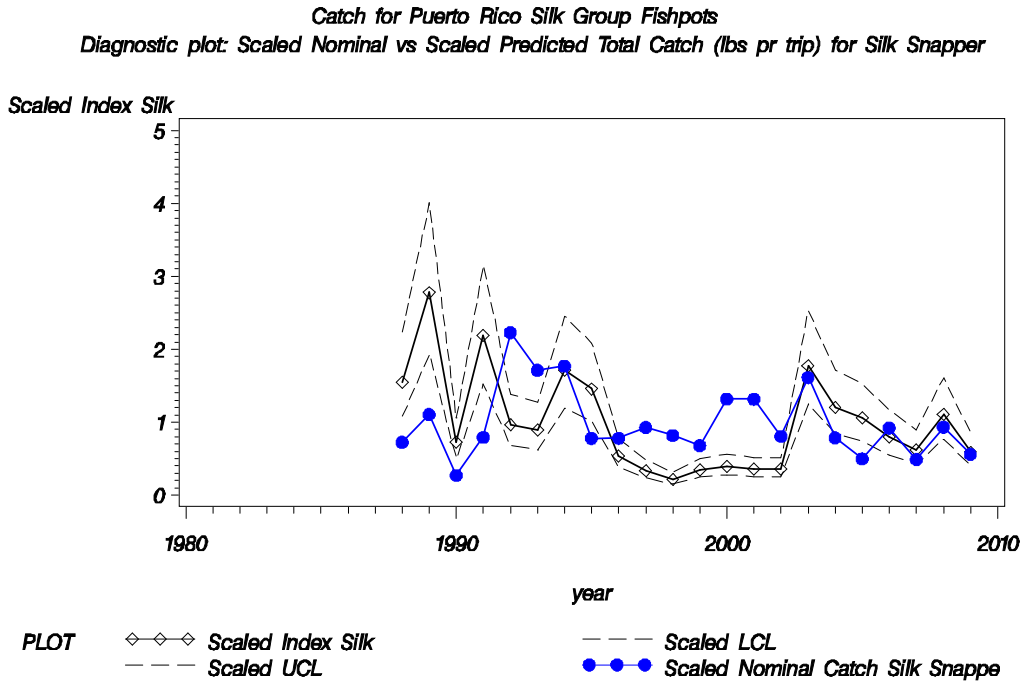
Catch for Puerto Rico Silk Group Handlines
Diagnostic plot: Scaled Nominal vs Scaled Predicted Total Catch (lbs pr trip) for Silk Snapper



Silk Group Fishpots Multinomial – Effort: number per trap

Class Level Information

Class	*Levels*	*Values*
yr	22	1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
quarter	4	1 2 3 4
month	12	1 2 3 4 5 6 7 8 9 10 11 12
coast	4	EAST NORTH SOUTH WEST
FISHING_CENTER	63	010 011 050 060 061 062 080 090 100 120 121 130 131 132 140 150 151 152 153 160 161 180 181 182 183 200 201 220 221 230 250 251 280 281 282 320 321 360 361 362 370 371 372 373 374 375 376 377 380 381 382 383 384 390 400 401 402 410 411 420 421 422 423
PR_GEAR_CODE	1	101

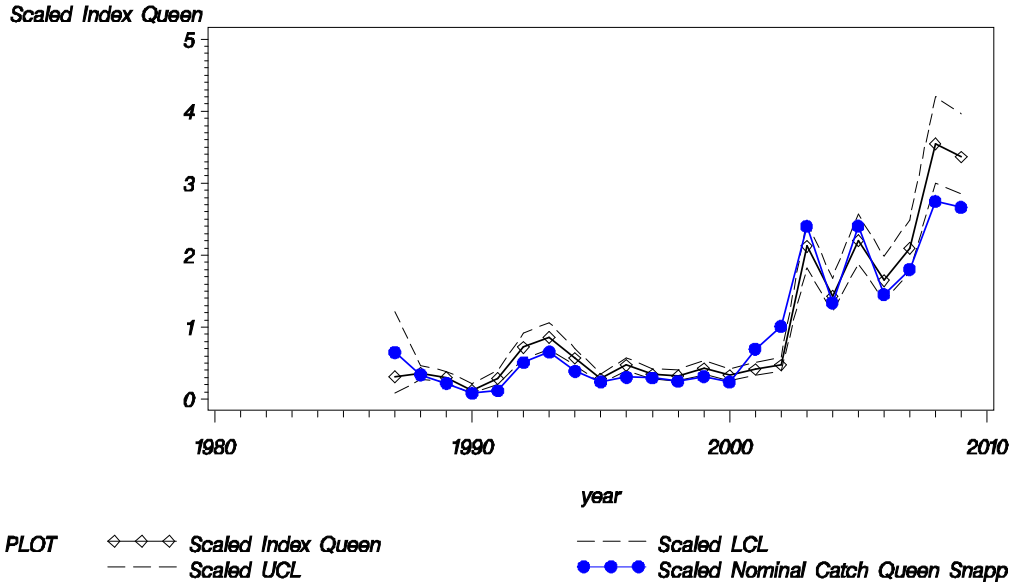


Queen Group Handlines Multinomial – Effort: hook-hours

Class Level Information

Class	*Levels*	*Values*
yr	23	1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
quarter	4	1 2 3 4
month	12	1 2 3 4 5 6 7 8 9 10 11 12
coast	4	EAST NORTH SOUTH WEST
FISHING_CENTER	54	010 011 050 060 061 120 121 130 131 132 150 151 152 153 160 161 200 201 280 281 282 320 321 350 351 352 353 360 361 362 370 371 372 373 374 375 376 377 380 381 382 383 384 390 400 401 402 403 410 411 420 421 422 423
PR_GEAR_CODE	2	104 105

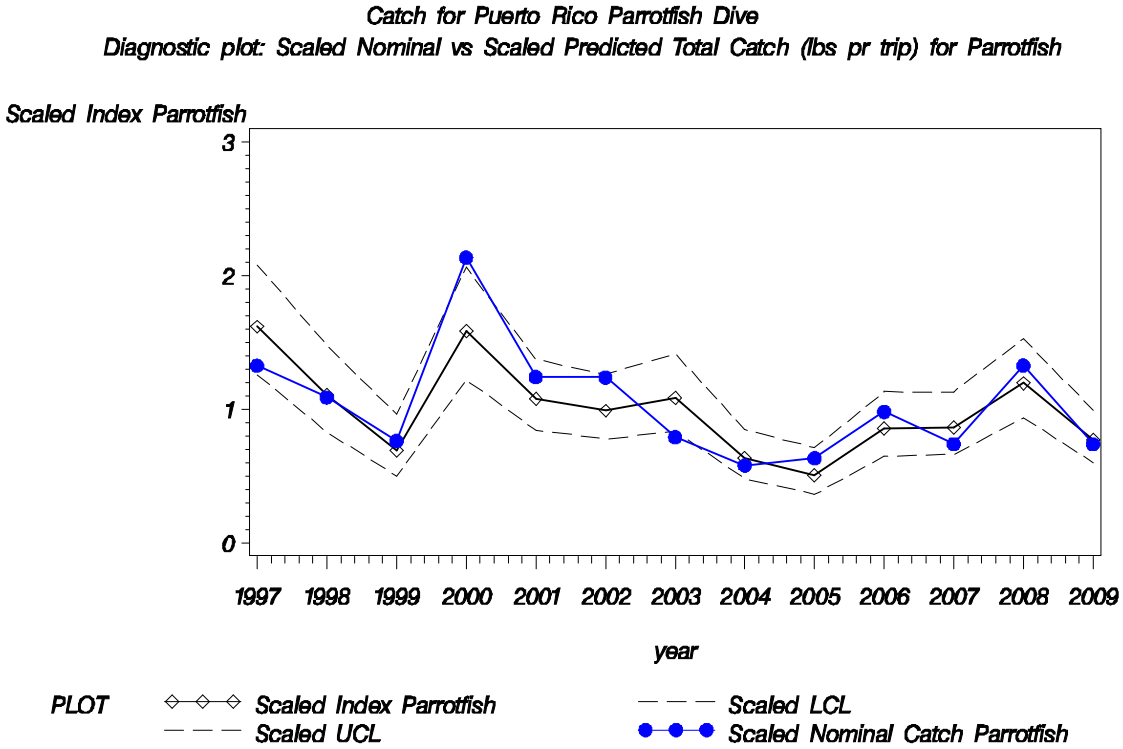
Catch for Puerto Rico Queen Group Handlines
Diagnostic plot: Scaled Nominal vs Scaled Predicted Total Catch (lbs pr trip) for Queen Snapper



Parrotfish Dive Multinomial – Effort: number per trip

Class Level Information

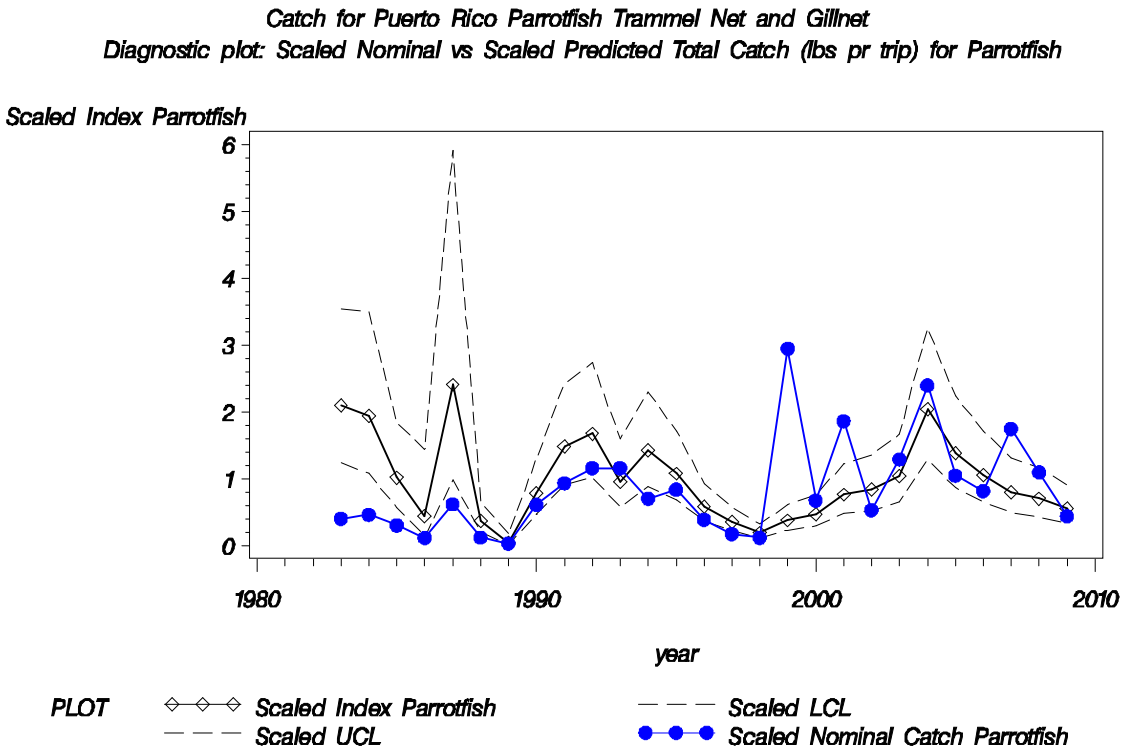
Class	Levels	Values
yr	13	1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
quarter	4	1 2 3 4
month	12	1 2 3 4 5 6 7 8 9 10 11 12
coast	4	EAST NORTH SOUTH WEST
FISHING_CENTER	40	140 180 181 182 183 190 191 200 201 210 211 212 240 250 251 270 330 340 341 350 351 352 353 360 361 362 370 371 372 373 374 375 376 377 380 381 382 384 400 401
PR_GEAR_CODE	5	110 114 115 116 119



Parrotfish Trammel Net and Gillnet Multinomial – Effort: length (fathoms) by hours soaked

Class Level Information

Class	Levels	Values
yr	27	1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
quarter	4	1 2 3 4
month	12	1 2 3 4 5 6 7 8 9 10 11 12
coast	3	EAST SOUTH WEST
FISHING_CENTER	17	230 270 350 351 352 353 360 361 362 370 371 372 373 374 375 376 377
PR_GEAR_CODE	2	103 118

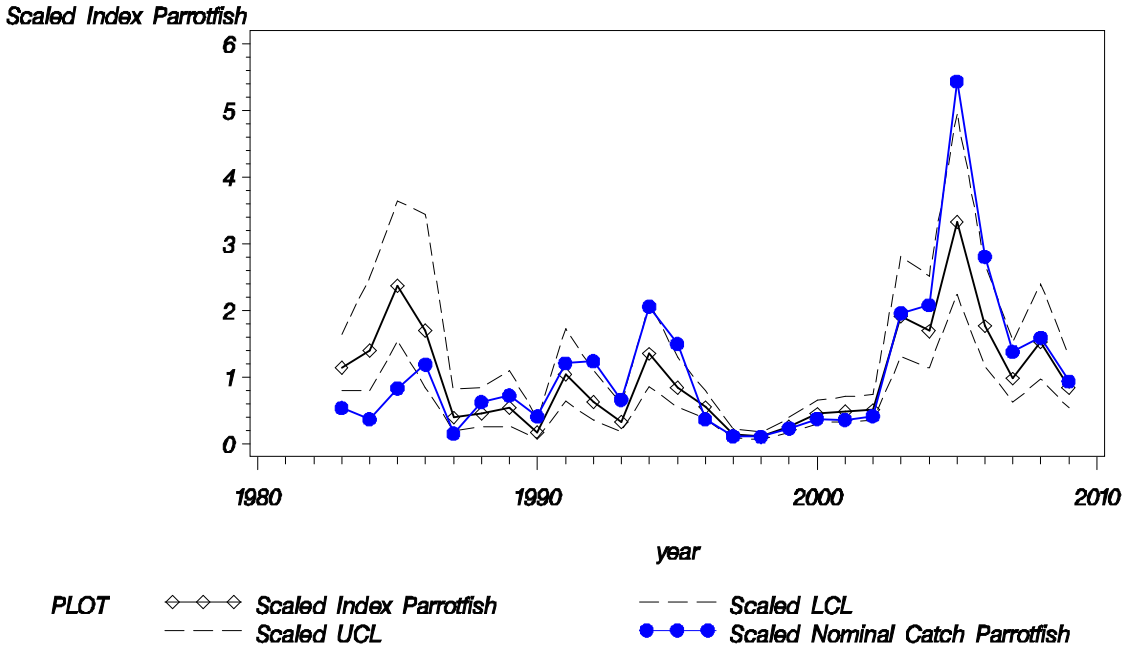


Parrotfish Fishpots Multinomial – Effort: number per trap

Class Level Information

Class	Levels	Values
yr	27	1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
quarter	4	1 2 3 4
month	12	1 2 3 4 5 6 7 8 9 10 11 12
coast	3	EAST SOUTH WEST
FISHING_CENTER	37	180 181 182 183 190 191 200 201 210 211 212 220 221 230 240 250 251 270 280 281 282 290 291 292 310 311 360 361 362 370 371 372 373 374 375 376 377
PR_GEAR_CODE	1	101

Catch for Puerto Rico Parrotfish Fishpots
Diagnostic plot: Scaled Nominal vs Scaled Predicted Total Catch (lbs pr trip) for Parrotfish

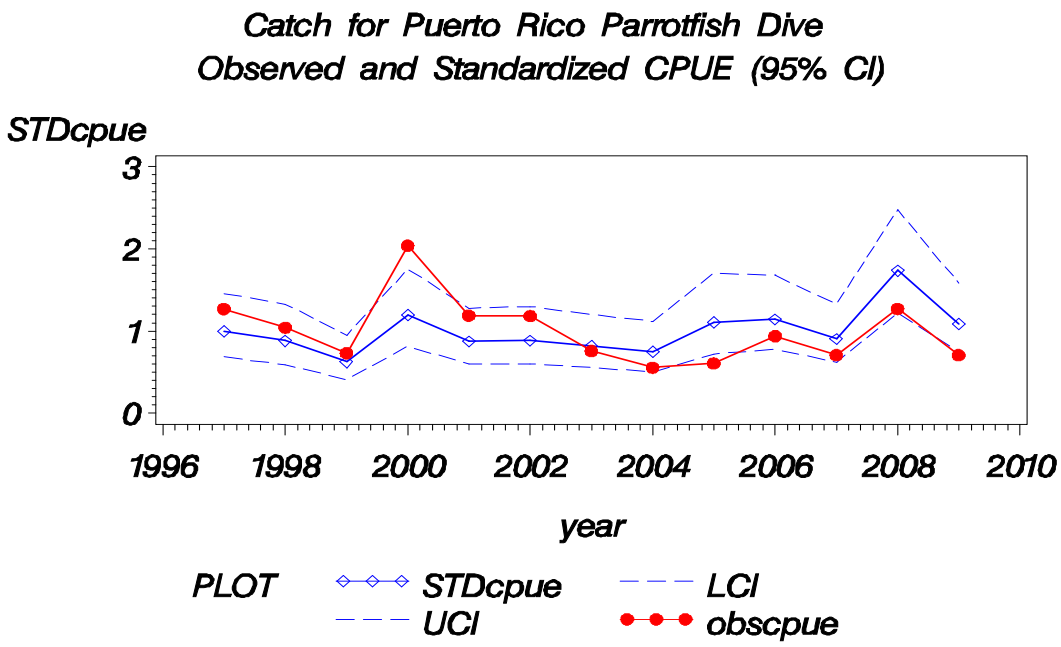


Parrotfish Dive Delta-Lognormal – Effort: number per trip

Class Level Information

Class	*Levels*	*Values*
year	13	1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
quarter	4	1 2 3 4
coast	4	EAST NORTH SOUTH WEST
ID_CODE	549	000000 000004 000011 000038 000063 000075 000109 000134 000140 000141 000142 000166 000182 000200 000212 000217 000241 000247 000248 000249 000260 000273 000279 000313 000367 000369 000375 000485 000509 000512 000513 000553 000561 000562 000565 000595 000611 000631 000643 000735 000770 000775 000783 000789 000807 000827 000840 000878 000920 000937 000942 000954 000957 000965 000987 001006 001015 001031 001055 001060 001061 001092 001105 001112 001123 001128 001132 001143 001150 001151 001160 001165 001171 001172 001182 001192 001198 001226 001228 001306 001307 001375 001376 001393 001405 001418 001420 001456 001467 001501 001523 001535 001543 001579 001593 001600 001635 001637 001679 001688 001695 001705 001724 001738 001783 001807 001813 001821 001831 001858 001864 001880 001884 001896 001911 001912 001949 001992 002007 002008 002034 002037 002043 002044 002054 002062 002063 002064 002089 002095 002129 002228 002280 002362 00240x 002462 002466 002473 002486 002504 002574 002615 002647 002666 002684 002708 002736 002745 002765 002792 002818 002831 002837 002853 002863 002865 002906 002988 002995 002998 003035 003056 003085 003137 003142 003143 003176 003196 003215 003234 003239 003252 003273 003307 003311 003345 003359 003365 003366 003375 003583 003600 003614 003695 003742 003753 003762 003781 003790 003791 003792 003795 003832 003837 003854 003890 003905 004033 004069 004086 004206 004234 004298 004394 004421 004429 004488 004524 004558 004564 004593 004663 004707 004824 004914 004952 004959 004960 005005 005030 005146 005318 005423 005695 005906 005966 005974 006025 006032 006035 006038 006054 006182 006214 006242 006247 006248 006638 006670 006742 006951 007086 007117 007162 007211 007214 007254 007296 007308 007365 007387 007404 007418 007431 007504 007544 007575 007740 007748 007778 007786 007788 007879 007940 008272 008370 008400 008401 008600 008635 008781 008857 008872 009038 009160 009269 009270 009431 009610 009624 009660 009663 009692 009805 009825 009852 009872 009878 009903 009906 009931 010466 010468 010573 010580 010792 010829 010850 010861 010869 010936 010960 010966 011005 011112 011300 011425 011473 011565 011597 011599 011608 011821 011957 011967 011977 011982 012035 012037 012078 012104 012105 012117 012186 012189 012280 012284 012301 012355 012375 012377 012401 012407 012425 012439 012455 012461 012484 012485 012488 012503 012538 012568 012635 012651 012666 012763 012817 012835 012836 012852 012942 013027 013033 013051 013065 013081 013108 013118 013125 013155 013194 013261 013315 013334 013370 013384 013400 013427 013434 013450 013464 013487 013560 013622 013662 013680 013684 013737 013857 014061 014107 014186 014211 014223 014261 014357 014435 014475 014641 015906 125381 181009 18200X 182025 183030 190008 201003 20100X 201012 201033 201049 210001 210002 210004 21000X 210037 210042 24000X 250003 25000X 250012 250013 250051 27000X 270017 27001X 27002X 27003X 27007X 27016X 27017X 290701 300004 330001 330002 330003 330004 330005 330006 330007 330009 33000A 33000B 33000D 33000E 33000F 33000G 33000I 33000L 33000M 33000R 33000S 33000U 33000W 33000X 33000Y 33000Z 330010 330011 330012 330013 330014 330019 330021 330023 330030 330042 330050 330051 330055 330056 350002 350003 350005 350006 350007 35000X 350012 350016 350026 350047 350060 351001 351002 351003 351004 351005 351006 351007 351008 351009 351016 351020 351022 351036 351038 351056 351082 35300X 36000X 360012 37100X 371058 373039 37400X 374014 374027 374051 374063 374079 374080 37700X 380071 380084 38100A 38100B 38100C 38100H 38100L 38100M 38100X 38100Y 792774 N00134 N00200 N00249 N00512 N00959 N01031 N01519 SS0718 SS1053 SS1163 SS1406 SS1485 SS2824 SS2915 SS3085 SS3460 SS3660 SS3661 SS3907 SS3960 SS4564 SS6264 SS6414 SS6631 SS6682 SS7214 SS7615 SS7982 SS8060 SS8342 SS9513 SS9795 ss6108 ss6184 ss7214

Parrotfish Dive Delta-Lognormal continued– Effort: number per trip



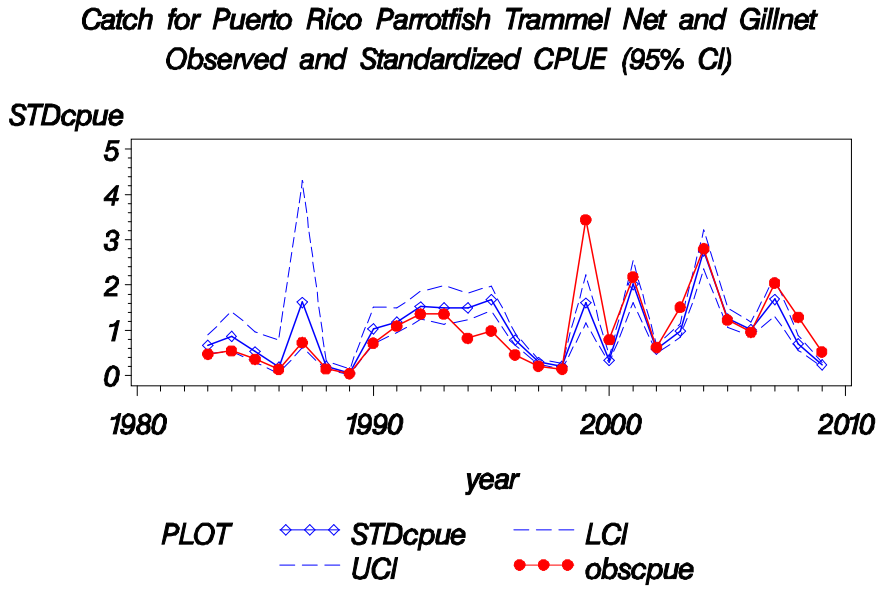
SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1997	0.13329	4194	2.49370	0.99739	0.19073	0.68340	1.45564
1998	0.09819	2536	2.20685	0.88266	0.20531	0.58790	1.32521
1999	0.07437	3523	1.55970	0.62382	0.21175	0.41035	0.94835
2000	0.12735	4476	2.98586	1.19423	0.19451	0.81228	1.75579
2001	0.11921	6451	2.18543	0.87409	0.19050	0.59919	1.27512
2002	0.11096	6074	2.21006	0.88394	0.19418	0.60162	1.29876
2003	0.09241	6623	2.04287	0.81707	0.19435	0.55593	1.20090
2004	0.05083	8125	1.87029	0.74805	0.20310	0.50038	1.11830
2005	0.03361	6813	2.77035	1.10804	0.21851	0.71940	1.70663
2006	0.09209	6374	2.85771	1.14298	0.19372	0.77861	1.67786
2007	0.09487	7136	2.26229	0.90483	0.19258	0.61776	1.32531
2008	0.12447	7480	4.34202	1.73665	0.17943	1.21645	2.47931
2009	0.08671	8096	2.71587	1.08625	0.18949	0.74609	1.58149

Parrotfish Trammel Net and Gillnet Delta-Lognormal – Effort: length (fathoms) by hours soaked

Class Level Information

Class	*Levels*	*Values*
year	27	1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
quarter	4	1 2 3 4
coast	3	EAST SOUTH WEST
ID_CODE	1120	000001 000012 000041 000052 000079 000081 000131 000140 000148 000161 000181 000185 000199 000209 000252 000310 000313 000315 000363 000367 000368 000369 000380 000382 000460 000479 000503 000512 000513 000523 000561 000562 000563 000573 000604 000611 000632 000653 000657 000664 000686 000692 000756 000771 000858 000886 000890 000895 000956 000957 000959 000965 000980 000984 000985 000996 001006 001007 001015 001028 001029 001041 001055 001065 001082 001092 001095 001128 001129 001143 001148 001153 001163 001180 001193 001226 001228 001232 001255 001290 001298 001373 001376 001384 001393 001396 001406 001418 001420 001440 001457 001482 001485 001504 001507 001513 001522 001523 001543 001545 001546 001547 001548 001563 001579 001588 001589 001598 001600 001660 001685 001697 001705 001710 001738 001832 001835 001843 001862 001880 001889 001903 001988 002004 002028 002031 002043 002044 002073 002087 002108 002114 002169 002201 002205 002242 002310 002313 002318 002340 002353 002356 002361 002364 002383 002385 002391 002403 002407 002464 002466 002467 002480 002491 002497 002501 002504 002506 002528 002532 002573 002574 002579 002610 002611 002636 002640 002649 002664 002666 002674 002685 002687 002694 002697 002708 002710 002717 002731 002732 002736 002738 002739 002742 002749 002752 002764 002765 002779 002784 002787 002833 002860 002864 002889 002908 002910 002923 002929 002947 002968 002988 002989 003013 003025 003037 003093 003097 003101 003103 003104 003205 003207 003208 003215 003231 003256 003273 003283 003334 003336 003343 003353 003358 003359 003366 003385 003389 003432 003460 003461 003463 003464 003471 003479 003485 003519 003521 003522 003526 00360x 00361X 003622 003631 003651 003696 003718 00373x 00374x 003791 003850 003854 003856 003883 004072 004096 004140 004219 004232 004236 004237 004282 004292 004488 004545 004581 004592 004593 004690 004758 004769 004803 004810 004914 004917 004920 004960 004987 004994 005129 005248 005285 005289 005519 005525 005534 005695 005696 005885 005898 006000 006089 006128 006188 006196 006205 006217 006240 006245 006246 006248 006278 006298 006330 006408 006414 006448 006513 006640 006646 006670 006674 006711 006951 007086 007117 007120 007202 007205 007206 007327 007507 007544 007575 007605 007660 007664 007726 007740 007741 007748 007786 007879 007922 008116 008134 008141 008149 008253 008351 008354 008356 008364 008395 008461 008484 008500 008532 008556 008721 008916 008996 009021 009180 009214 009219 009238 009453 009533 009536 009540 009566 009610 009627 009632 009655 009656 009657 009670 009679 009805 009810 009850 009852 362009 36200X 362010 362011 362012 362013 362014 362015 362016 362017 362018 362019 362021 362024 362025 362029 362030 362031 362033 362035 362052 362058 370003 370005 370007 370016 370023 370035 370056 371001 371002 371003 371004 371005 371006 371007 371008 371009 37100X 371010 371011 371012 371013 371014 371015 371017 371018 371020 371021 371022 371023 371024 371025 371026 371027 371028 371030 371031 371032 371033 371034 371035 371036 371037 371038 371039 371040 371044 371047 371048 371050 371051 371052 371054 371055 371056 371058 371059 371061 371064 371065 371069 371070 371071 371072 371073 371074 371076 371087 371096 371119 372002 372004 372005 372006 372007 372008 37200X 372012 372014 372017 372018 372022 372024 372025 372028 372029 372030 372031 372033 372035 372036 372040 372041 372046 372058 372062 372066 372067 372069 372070 372071 372080 373001 373002 373003 373004 373005 373006 373007 373008 37300X 373010 373011 373012 373013 373014 373015 373016 373017 373018 373019 373021 373022 373023 373024 373025 373026 373027 373028 373030 373031 373032 373033 373034 373035 373036 373037 373038 373039 373041 373044 373046 373047 373048 373049 373053 373054 373063 373064 373065 373084 373105 373106 373109 373111 373114 373115 373120 373127 373134 374002 374003 374005 374006 374007 37400X 37400x 374010 374011 374012 374013 374014 374016 374018 374019 374020 374021 374022 374027 374030 374037 374038 374045 374048 374049 374052 374058 374078 374082 374087 374090 374091 374094 374114 374122 374127 374129 374143 374146 374152 374163 374164 374167 374174 374196 374206 374246 375004 375009 37500X 375014 376003 376004 376006 376007 376008 377004 377012 377025 499080 599810 612187 612509 808395 880416 938742 953366 961523 962043 962044 962187 962736 967086 968356 N00041 N00051 N00052 N00079 N00081 N00086 N00148 N00313 N00368 N00369 N00448 N00479 N00513 N00611 N00632 N00653 N00657 N00680 N00686 N00895 N00959 N01039 N01055 N01129 N01180 N01255 N01393 N01418 SS0497 SS1163 SS1373 SS1473 SS1760 SS2004 SS2182 SS2540 SS2675 SS2685 SS2697 SS3075 SS3343 SS3661 SS3781 SS4072 SS4178 SS4934 SS5135 SS5191 SS5198 SS5911 SS6414 SS7247 SS7605 SS8230 SS8395 SS8526 SS8731 SS8826 SS8895 SS8926 SS9180 SS9391 SS9395 SS9780 SS9906 ss2685 ss3343 ss4613 ss5449 ss6184 ss7605 ss7655 ss7741 ss8731

Parrotfish Trammel Net and Gillnet Delta-Lognormal continued – Effort: length (fathoms) by hours soaked



Parrotfish Trammel Net and Gillnet Delta-Lognormal continued – Effort: length (fathoms) by hours soaked

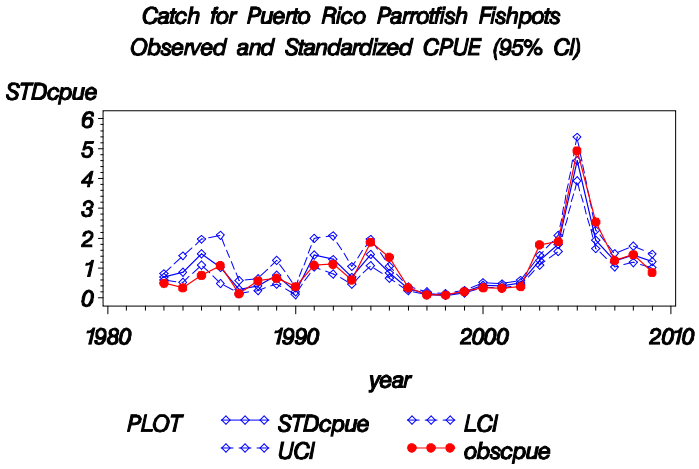
SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1983	0.27374	179	0.03535	0.66478	0.15429	0.48916	0.90346
1984	0.22124	113	0.04639	0.87225	0.24510	0.53808	1.41396
1985	0.27350	117	0.02815	0.52933	0.30925	0.28922	0.96879
1986	0.19048	21	0.00979	0.18412	0.82626	0.04350	0.77929
1987	0.38462	13	0.08615	1.61996	0.52078	0.60815	4.31517
1988	0.06423	794	0.01110	0.20867	0.20656	0.13865	0.31405
1989	0.00862	580	0.00293	0.05501	0.50494	0.02121	0.14269
1990	0.12634	744	0.05478	1.03018	0.19507	0.69993	1.51626
1991	0.22111	701	0.06316	1.18766	0.11432	0.94563	1.49163
1992	0.38761	436	0.08080	1.51936	0.10100	1.24208	1.85853
1993	0.24597	496	0.07973	1.49929	0.14133	1.13172	1.98624
1994	0.32663	845	0.07960	1.49690	0.09817	1.23063	1.82077
1995	0.30577	1403	0.08926	1.67848	0.08279	1.42276	1.98015
1996	0.26392	2012	0.04200	0.78982	0.08550	0.66588	0.93683
1997	0.22949	1987	0.01573	0.29572	0.09266	0.24579	0.35580
1998	0.13947	1011	0.01066	0.20036	0.13889	0.15197	0.26417
1999	0.17083	1241	0.08536	1.60508	0.16414	1.15843	2.22394
2000	0.22021	1267	0.01801	0.33862	0.09683	0.27912	0.41079
2001	0.22810	1701	0.10733	2.01831	0.11563	1.60283	2.54150
2002	0.29473	1537	0.03080	0.57916	0.07924	0.49440	0.67845
2003	0.26229	2116	0.05226	0.98274	0.07837	0.84038	1.14923
2004	0.32381	1680	0.14626	2.75027	0.07928	2.34757	3.22206
2005	0.31088	1232	0.06692	1.25837	0.08562	1.06066	1.49294
2006	0.36164	1001	0.05387	1.01306	0.07802	0.86691	1.18386
2007	0.26502	1132	0.08971	1.68693	0.12515	1.31466	2.16462
2008	0.28032	1006	0.03719	0.69937	0.11830	0.55247	0.88533
2009	0.29925	1203	0.01256	0.23619	0.08501	0.19932	0.27988

Parrotfish Fishpots Delta-Lognormal – Effort: number per trap

Class Level Information

Class	*Levels*	*Values*
year	27	1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
quarter	4	1 2 3 4
coast	3	EAST SOUTH WEST
ID_CODE	3168	000003 000006 000008 000013 000016 000020 000024 000025 000027 000028 000029 000038 000039 000043 000045 000052 000059 000081 000083 000086 000098 000109 000112 000114 000123 000131 000132 000141 000142 000166 000168 000171 000175 000176 000182 000198 000204 000209 000213 000228 000231 000233 000234 000236 000238 000241 000244 000245 000247 000248 000249 000252 000253 000256 000263 000264 000267 000274 000277 000278 000281 000285 000302 000306 000309 000310 000313 000321 000322 000336 000347 000360 000367 000368 000369 000371 000378 000382 000385 000386 000408 000411 000421 000437 000445 000447 000449 000472 000474 000497 000509 000561 000562 000565 000580 000592 000596 000600 000611 000618 000619 000621 000623 000630 000632 000638 000643 000651 000653 000655 000657 000672 000675 000678 000682 000690 000692 000730 000735 000743 000754 000768 000773 000775 000777 000781 000785 000788 000805 000810 000813 000842 000849 000852 000865 000869 000878 000881 000882 000893 000895 000897 000913 000915 000917 000924 000934 000939 000942 000945 000957 000959 000960 000963 000965 000975 000980 000981 000984 000985 000988 001004 001005 001006 001007 001008 001012 001015 001016 001019 001026 001029 001031 001040 001041 001044 001045 001047 001055 001057 001060 001061 001065 001078 001083 001086 001098 001112 001113 001117 001128 001134 001161 001162 001163 001165 001169 001171 001174 001184 001197 001198 001202 001213 001218 001222 001225 001227 001232 001237 001245 001249 001262 001269 001275 001279 001286 001290 001294 001295 001298 001300 001306 001307 001308 001309 001320 001324 001325 001333 001338 001340 001342 001384 001386 001388 001391 001392 001394 001401 001403 001406 001413 001420 001421 001423 001425 001431 001438 001440 001444 001453 001462 001467 001482 001485 001503 001507 001510 001516 001523 001525 001532 001546 001552 001553 001556 001561 001563 001566 001571 001573 001580 001583 001589 001595 001598 001621 001627 001651 001652 001660 001675 001687 001701 001710 001711 001716 001717 001735 001755 001760 001762 001763 001767 001768 001775 001782 001785 001790 001798 001799 001800 00180x 001811 001862 001863 001867 372056 372062 372065 372072 372074 372076 372206 372228 372372 372506 373001 373002 373003 373004 373006 373007 373008 37300X 373010 373011 373012 373013 373014 373015 373016 373017 373018 373019 373021 373022 373023 373024 373025 373027 373029 373030 373032 373033 373035 373037 373038 373039 373040 373044 373045 373047 373048 373049 373053 373064 373067 373079 373084 373104 373105 373106 373107 373108 373109 373110 373114 373116 373117 373119 373120 373121 373122 373123 373126 374001 374002 374003 374004 374005 374006 374007 374008 374009 37400E 37400X 374010 374011 374012 374013 374014 374015 374016 374017 374018 374019 374020 374021 374022 374023 374024 374025 374026 374027 374028 374029 374031 374032 374033 374034 374035 374036 374038 374040 374041 374042 374043 374044 374045 374046 374047 374048 374049 374050 374051 374052 374053 374054 374055 374057 374058 374059 374060 374061 374062 374063 374064 374066 374067 374069 374070 374071 374072 374074 374075 374078 374079 374080 374081 374082 374085 374086 374087 374090 374091 374094 374095 374096 374097 374098 374103 374106 374107 374109 374110 374113 374116 374117 374120 374121 374122 374123 374128 374130 374132 374134 374140 374146 374151 374162 374163 374164 374165 374166 374167 374168 374169 374172 374175 374177 374182 374184 374194 374195 374196 374200 374219 374220 374232 374235 375001 375002 375003 375004 375005 375006 375008 375009 375010 375013 375014 375019 375041 375044 375067 375075 375091 375102 375902 376001 376002 376003 376004 376005 376006 376007 376008 37600X 376011 376018 376020 376021 376022 376023 377001 377002 377003 377004 377005 377006 377007 377008 377009 377011 377012 377013 377022 377029 377030 377033 378005 387865 387965 42000X 512224 545694 545695 567741 599810 600321 612509 645695 712569 713252 723775 728959 730533 778528 778828 808395 880416 880496 904681 922561 930115 947001 961299 961523 961762 962044 964987 964992 967086 968356 968587 N00043 N00045 N00052 N00081 N00083 N00109 N00123 N00132 N00143 N00144 N00148 N00175 N00209 N00233 N00236 N00238 N00247 N00248 N00249 N00272 N00277 N00278 N00279 N00302 N00305 N00306 N00313 N00321 N00322 N00334 N00360 N00369 N00378 N00381 N00386 N00408 N00437 N00445 N00447 N00496 N00590 N00596 N00611 N00618 N00630 N00653 N00678 N00682 N00691 N00714 N00735 N00754 N00777 N00805 N00849 N00852 N00881 N00897 N00945 N00975 N00984 N00988 N01006 N01031 N01045 N01047 N01055 N01126 N01134 N01161 N01168 N01171 N01198 N01202 N01215 N01222 N01225 N01245 N01306 N01326 N01354 N01573 N01580 N01583 SS0032 SS0098 SS0241 SS0405 SS0495 SS0688 SS0718 SS0929 SS0965 SS1031 SS1163 SS1264 SS1406 SS1473 SS1493 SS1556 SS1704 SS1896 SS1898 SS2008 SS2333 SS2463 SS2742 SS2912 SS2915 SS2923 SS3053 SS3075 SS3085 SS3095 SS3107 SS3212 SS3252 SS3661 SS3707 SS3775 SS3882 SS3892 SS3976 SS3998 SS4080 SS4178 SS4515 SS4714 SS4932 SS5115 SS5165 SS5189 SS5191 SS5290 SS5305 SS5331 SS5496 SS5689 SS5695 SS5711 SS5787 SS5789 SS5809 SS5911 SS5940 SS6315 SS6631 SS6908 SS6999 SS7083 SS7332 SS7462 SS7525 SS7532 SS7605 SS7672 SS7982 SS8230 SS8395 SS8526 SS8528 SS8603 SS8724 SS8767 SS8926 SS8992 SS9180 SS9201 SS9291 SS9395 SS9627 SS9699 SS9784 SS9795 SS9835 SS9967 SS9981 ss0026 ss0142 ss0611 ss0768 ss1896 ss2384 ss3075 ss3085 ss3107 ss4315 ss4613 ss4681 ss5449 ss6184 ss6631 ss7532 ss7605 ss7741 ss8395 ss9330 ss9699 ss9927 ss9929

Parrotfish Fishpots Delta-Lognormal continued– Effort: number per trap



Parrotfish Fishpots Delta-Lognormal continued– Effort: number per trap

SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1983	0.23919	2659	0.19469	0.69559	0.07882	0.59429	0.81416
1984	0.09380	597	0.23972	0.85646	0.25370	0.51972	1.41136
1985	0.27427	649	0.41256	1.47398	0.14546	1.10359	1.96869
1986	0.19136	162	0.28365	1.01343	0.37748	0.48840	2.10287
1987	0.10811	222	0.08000	0.28582	0.36961	0.13972	0.58466
1988	0.02520	3056	0.11243	0.40168	0.23826	0.25106	0.64266
1989	0.01493	3750	0.21280	0.76029	0.25859	0.45708	1.26463
1990	0.01384	2674	0.05791	0.20691	0.29462	0.11620	0.36846
1991	0.04322	3332	0.40324	1.44070	0.16522	1.03760	2.00041
1992	0.05992	1235	0.36180	1.29265	0.24177	0.80253	2.08211
1993	0.04577	2010	0.19460	0.69526	0.21032	0.45860	1.05404
1994	0.06155	2697	0.40815	1.45823	0.15080	1.08039	1.96821
1995	0.05353	4969	0.23372	0.83504	0.12016	0.65722	1.06098
1996	0.06497	4448	0.08323	0.29737	0.11515	0.23638	0.37410
1997	0.02980	4598	0.04157	0.14853	0.16913	0.10616	0.20782
1998	0.05467	3402	0.02957	0.10563	0.14189	0.07965	0.14010
1999	0.08012	4568	0.05813	0.20770	0.10027	0.17004	0.25369
2000	0.13094	3933	0.12022	0.42951	0.09032	0.35866	0.51435
2001	0.13176	4288	0.11191	0.39984	0.08640	0.33650	0.47510
2002	0.14089	4656	0.14238	0.50870	0.07612	0.43696	0.59222
2003	0.22643	3648	0.35071	1.25301	0.06679	1.09650	1.43185
2004	0.21887	2883	0.50460	1.80283	0.07521	1.55138	2.09504
2005	0.25306	2288	1.28640	4.59605	0.07947	3.92165	5.38642
2006	0.31139	1747	0.54091	1.93257	0.07952	1.64883	2.26512
2007	0.27559	1524	0.34861	1.24552	0.08916	1.04246	1.48812
2008	0.32407	1188	0.40247	1.43795	0.09524	1.18908	1.73892
2009	0.24293	1663	0.34112	1.21876	0.09343	1.01143	1.46857