STANDARDIZED CATCH RATE INDICES FOR VERMILION SNAPPER (*RHOMBOPLITES AURORUBENS*) LANDED BY THE U.S. COMMERCIAL HANDLINE FISHERY IN THE GULF OF MEXICO DURING 1993-2004

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SEDAR9-DW5

ABSTRACT

Standardized catch rate indices (delta-lognormal) were constructed for the SEDAR9 (vermilion snapper) data workshop (New Orleans, Louisiana, June 2005). The indices were constructed using two approaches: subsetting the trips using species composition to infer habitat, and including all Gulf of Mexico handline trips while accounting for the influence of gear configuration. In each case, gulfwide and regional indices (eastern and western) were developed. All the indices were constructed using NMFS Gulf of Mexico Reef Fish Logbook data. The gulfwide and western indices generally decline from 1993-2000 and increase thereafter. The eastern indices exhibit a stronger decline from 1993-2000, and then remain at low levels.

INTRODUCTION

Commercial vessels operating in the Gulf of Mexico have been monitored by the NMFS Gulf of Mexico Reef Fish Logbook Program since 1990. Catch and effort data from commercial handline trips occurring within the Gulf of Mexico were used to develop standardized catch rate indices for vermilion snapper. This document describes the development of the indices which are presented for the consideration of the SEDAR9-DW panel (New Orleans, Louisiana, June 2005).

METHODS

Data Sources

The NMFS Gulf of Mexico Reef Fish Logbook Program collects catch and effort data by trip for permitted vessels that participate in fisheries managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. The program began in 1990 with a complete census of commercial reef fish trips by vessels permitted in TX, LA, MS and AL. A 20% sample of vessels permitted in FL was required until 1993, when all permitted reef fish vessels were required to submit logs. We constructed catch rate indices for the period 1993-2004, because we have concerns that the data prior to 1993 is unreliable.

Most vermilion snapper landed by commercial vessels is landed using handline and electric reels (the two gear types were considered equivalent). Thus, the analysis was restricted to vessels employing those gear types. The logbook data base includes unique trip and vessel identifiers and information regarding trip date, gear class, fishing area (identical to shrimp statistical grid; Fig. 1), days at sea, fishing effort, species caught and landed weight. A vessel may fish in multiple areas using multiple gears on a single trip. However, while catch is reported by gear and area, effort is not. Instead total effort by gear is reported for each trip. Therefore it is not possible to calculate the catch per unit effort by area on trips that fished in more than one area. For this reason, trips that fished in multiple areas were excluded from the analysis. In addition, data were restricted to those trips occurring within the U.S Gulf of Mexico (areas 1-21; Fig. 1).

Not all commercial reef fish trips target vermilion snapper, or occur in habitat where vermilion snapper commonly occur. Inclusion of trips fishing outside of the habitat of the species of interest can contaminate CPUE indices (Stephens and McCall, 2004). As direct information useful to infer targeting (fine-scale fishing location, fishing depth, bait choice, target species) is not recorded by the logbook program, it was necessary to subset the data using indirect methods. Two approaches were used, a “species composition” approach developed by Stephens and McCall (2004) and a “gear configuration” approach that included all trips, but applied a gear configuration factor (hooks per line) to address the effects of targeting. The gear configuration approach was attempted based on information by port agents that vessels targeting vermilion snapper are more likely to use numerous hooks on a line while vessels targeting groupers use few.

Subsetting data for CPUE analysis using species composition

We used an objective approach recently developed by Stephens and McCall (2004) to subset logbook trip records using species composition. This method uses the observed species composition of a fishing trip to infer if that trip’s effort occurred in the habitat of the target species (vermilion snapper). Species composition was examined in two regions, the eastern gulf (areas 1-12) and the western gulf (areas 13-21). Trips were subset by region, and then combined for the gulfwide analysis. Only those species occurring on at least 1% of all trips were considered.

The method is described in detail in Stephens and McCall (2004). A brief summary follows. First, the species composition from catch records is used to estimate the parameters of a logistic regression. For example, Let Y_j be a categorical variable describing the presence/absence of the non-target species for trip j. Similarly, let x_{ij} describe the presence/absence of vermilion snapper.

$$Y_j = \begin{cases} 1 & \text{if the target species is caught} \\ 0 & \text{if the target species is not caught} \end{cases}$$

Then a logistic regression is applied to estimate the probability that vermilion snapper would have been encountered on a trip. Using the regression results, a score (S_j) is assigned to each trip j as a function of the species encountered during that trip:

$$S_j = \exp \sum_{i=0}^{k} x_{ij}\beta_i$$

where the coefficients $\beta_1,\beta_2,\ldots\beta_k$ quantify the predictive effect of each species and β_0 is the intercept of the logistic regression.

This score is then converted into the probability of observing vermilion snapper given the vector of presence/absence of the other species observed on the trip (j).

$$\pi_j = \Pr\{Y_j = 1\} = \frac{S_j}{1 + S_j}$$

Given the coefficients $\beta_0, \beta_1, \ldots, \beta_k$ and the presence/absence indicators $x_{1j},\ldots, x_{kj}$, the log-likelihood (excluding constants independent of the parameters) is the sum:

$$L\{Y|\beta_0, \ldots, \beta_k, x_{1j}, \ldots, x_{kj}\} \quad = \sum_{j \in j+} \log(\pi_j) + \sum_{j \in j-} \log(1 - \pi_j)$$

where j+ indicates trips that landed vermilion snapper, and j- indicates trips where vermilion snapper were absent. The log-likelihood was maximized using the statistical package R (Ihaka and Gentleman, 1996). The estimated β coefficients reflect the association (positive or negative) between the non-target species and vermilion snapper, π_j is intended to estimate the probability that trip *j* occurred in the habitat of vermilion snapper.

Trips were selected for CPUE analysis using a critical value. The critical value was determined by examining the relationship between the critical value and the number of incorrect predictions. Both false positives (vermilion snapper predicted to occur when absent) and false negatives (vermilion snapper not expected to occur when present) were considered. The critical value that minimized the number of incorrect predictions was selected. Trips were included in the CPUE analysis if π (as calculated above) was above the critical value.

Index Development

For each index, the following factors were considered as possible influences on the proportion of trips that observed vermilion snapper, and the catch rates on positive trips. The factor commercial red snapper season RS_SEASON (OPEN/CLOSED) is defined in Table 1.

FACTOR	INDEX	LEVELS	VALUES
YEAR	ALL	12	1993-2004
SEASON	ALL	4	WIN = (Dec-Feb) SPR = (Mar-May) SUM = (Jun-Aug) AUT = (Sep-Nov)
Red Snapper PERMIT CLASS	ALL	3	Class 1, Class 2, No Red Snapper Permit
Red Snapper Commercial SEASON	ALL	2	Closed and Open
ZONE	GULFWIDE	4	SE GULF = (Areas 1-5) NE GULF (Areas 6-12) NW GULF = (Areas 13-16) SW GULF (Areas 17-21)
	EASTERN	2	SE GULF = (Areas 1-5) NE GULF (Areas 6-12)
	WESTERN	2	NW GULF = (Areas 13-16) SW GULF (Areas 17-21)
HOOKS_PER_LINE	ALL	3	LT10 = (1-9) LT20 = (10-19) GE20 = (20+)

A delta-lognormal approach (Lo et al., 1992) was used to develop the standardized catch rate indices. This method combines separate generalized linear modeling (GLM) analyses of the proportion positive trips[1] (trips that observed vermilion snapper) and the catch rate on successful trips[2] to construct a single standardized index of abundance. Parameterization of each model was accomplished using a GLM procedure (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc. Cary, NC, USA). For the lognormal models, the response variable, ln(CPUE), was calculated:

$$\ln(CPUE) = \ln(\text{pounds of vermilion snapper} / (\text{number of lines} * \text{hours fished}))$$

A forward stepwise approach was used during the construction of each GLM. First, a GLM model was fit on year. These results reflect the distribution of the nominal data. Next each potential factor was added to the null model individually, and the resulting reduction (%RED) in deviance per degree of freedom (DEV/DF) was examined. The factor that caused the greatest reduction in deviance per degree of freedom was added to the base model if the factor was significant based upon a Chi-Square test (PROBCHISQ≤0.05), and the reduction in deviance per degree of freedom was ≥1%. This model then became the base model, and the process was repeated, adding factors and two-way interaction terms individually until no factor or interaction met the criteria for incorporation into the final model. Higher order interaction terms were not examined.

The final delta-lognormal models were fitted using a SAS macro, GLIMMIX (glmm800MaOB.sas: Russ Wolfinger, SAS Institute). All factors were modeled as fixed effects except two-way interaction terms containing YEAR (e.g. YEAR*ZONE). These were modeled as random effects. To facilitate visual comparison, a relative index and relative nominal CPUE series were calculated by dividing each value in the series by the mean value of the series.

RESULTS AND DISCUSSION

[1] Type-3 model, error = binomial, link = logit, response variable = success (where success = 1 if vermilion snapper catch > 0, else success = 0)
[2] Type-3 model, error = normal, link = identity, response variable = logCPUE (where catch ≠ 0 and effort = lines * hours fished).

Subsetting CPUE data by species composition

Coefficients of the logistic regression reflect the association (positive or negative) between the non-target species and vermilion snapper. These are summarized in Tables 2-3. The results are generally as expected. For example, porgies, amberjack, gray triggerfish and red snapper are positively correlated to vermilion snapper while mangrove snapper, yellowtail snapper, blue-striped grunt and Spanish mackerel are negatively correlated.

Gulfwide Indices

Two gulfwide indices were constructed; one using species composition to define trips for inclusion in the analysis and a second using all trips.

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For the species composition approach, 40,938 total trips were identified as trips occurring in vermilion snapper habitat. Of these, 30,471 landed vermilion snapper. The final models for the binomial on proportion positive trips and the lognormal on CPUE were:

PPT= YEAR + HOOKS_PER_LINE + ZONE + RS_SEASON + ZONE*HOOKS_PER_LINE

LN(CPUE)= YEAR+ HOOKS_PER_LINE + RS_SEASON + ZONE
+ ZONE*HOOKS_PER_LINE + RS_SEASON*HOOKS_PER_LINE

The linear regression statistics are summarized in Table 4.

Using the gear configuration approach, 151,655 trips were included and 41,255 of these landed vermilion snapper. The final models for the binomial on proportion positive trips and the lognormal on CPUE were:

PPT= YEAR + HOOKS_PER_LINE + ZONE + PERMIT + ZONE*HOOKS_PER_LINE + YEAR*ZONE

LN(CPUE)= YEAR + HOOKS_PER_LINE + ZONE + RS_SEASON
+ ZONE*HOOKS_PER_LINE + RS_SEASON*HOOKS_PER_LINE

The linear regression statistics are summarized in Table 5.

There was little annual variation in the proportion of gulfwide trips that landed vermilion snapper (Fig. 2). Using the species composition approach, between 70% and 83% of the trips landed vermilion snapper each year. Using the gear composition approach (which does not exclude trips that occur outside vermilion snapper habitat) between 42% and 59% of the trips observed vermilion snapper each year.

Annual nominal CPUE (made relative by dividing each value by the series mean) was highest during 1993 and 1994, and then generally declined through 2000. Since 2000, nominal CPUE has increased, and during 2002-2004, the nominal CPUE was nearly equal to the series mean (Fig. 3). The two gulfwide delta-lognormal indices are very similar to the nominal CPUE series, and to each other. Both indices indicate declining catch rates from 1994-2000, and then increasing catch rates from 2000-2004. Gulfwide index results are summarized in Figs. 4-5 and Table 6.

Eastern Indices

The eastern CPUE data set developed using the species composition approach contained 21,867 total trips 15,893 of which landed vermilion snapper. The final models for the binomial on proportion positive trips and the lognormal on CPUE were:

PPT= YEAR + HOOKS_PER_LINE + ZONE

LN(CPUE)= YEAR + HOOKS_PER_LINE + ZONE + RS_SEASON + RS_SEASON*HOOKS_PER_LINE

The linear regression statistics are summarized in Table 7.

Using the gear configuration approach, 114,829 trips were included and 22,105 landed vermilion snapper. The final models for the binomial on proportion positive trips and the lognormal on CPUE were:

PPT= YEAR + HOOKS_PER_LINE + ZONE + PERMIT

LN(CPUE)= YEAR + HOOKS_PER_LINE + ZONE + RS_SEASON + RS_SEASON*HOOKS_PER_LINE

The linear regression statistics are summarized in Table 8.

The annual trends in proportion positive trips were very similar to those reported for the gulfwide procedures. Again, there was little annual variation in the proportion of trips that landed vermilion snapper (Fig. 6). Using the species composition approach, between 70% and 80% of the trips landed vermilion snapper each year. Using the gear composition approach between 16% and 22% of the trips landed vermilion snapper each year.

In the east, annual nominal CPUE was highest during 1993 and 1994, generally declined through 2000 and remained at low levels thereafter (Fig. 7). The two eastern delta-lognormal indices are very similar to the nominal CPUE series, to each other. Both indices indicate declining catch rates from 1994-2000, and then catch rates remain low from 2000-2004. Eastern index results are summarized in Figs. 8-9 and Table 9.

Western Indices

The western CPUE data set developed using the species composition approach contained 19,071 total trips 14,578 of which landed vermilion snapper. The final models for the binomial on proportion positive trips and the lognormal on CPUE were:

PPT= YEAR + PERMIT + RS_SEASON + ZONE + HOOKS_PER_LINE

LN(CPUE)= YEAR + RS_SEASON + ZONE + HOOKS_PER_LINE

The linear regression statistics are summarized in Table 10.

Using the gear configuration approach, 36,826 trips were included and 19,150 landed vermilion snapper. The final models for the binomial on proportion positive trips and the lognormal on CPUE were:

PPT= YEAR + HOOKS_PER_LINE + PERMIT + RS_SEASON + ZONE

LN(CPUE)= YEAR + RS_SEASON + ZONE

The linear regression statistics are summarized in Table 11.

Like the gulfwide and eastern treatments, there was little annual trend the proportion of positive trips (Fig. 10). Using the species composition approach, between 73% and 83% of the trips landed vermilion snapper each year. Using the gear composition approach between 42% and 60% of the trips landed vermilion snapper each year. There was a modest tendency toward increasing proportion positive trips during 2000-2004.

In the west, annual nominal CPUE declined from 1993-2000 (with the exception of a very high nominal CPUE in 1994. From 2000-2004, nominal CPUE increased to values just above the series mean (Fig. 11). The two western delta-lognormal indices are very similar to each other, although they are less similar to the nominal CPUE series. Both indices vary without obvious trend from 1994-2000, and then catch rates increase steeply from 2000-2004. The 2004 index estimates are the highest in the series. Western index results are summarized in Figs. 12-13 and Table 12.

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Table 1. Commercial Open Season Definitions.

YEAR	Start Open Season	End Open Season
1990	Always Open	
1991	Jan 1	Aug 24
1992	Jan 1	Feb 22
1992	Apr 3	Apr 30
1992	May 1	May 14
1993	Feb 16	May 20
1994	Feb 10	Apr 27
1995	Feb 24	Apr 14
1995	Nov 1	Nov 2
1996	Feb 1	Apr 5
1996	Sep 15	Oct 6
1997	Feb 1	Mar 25
1997	Sep 2	Sep 15
1997	Oct 1	Oct 6
1998	Feb 1	Feb 15
1998	Mar 1	Mar 15
1998	Apr 1	Apr 12
1998	Sep 1	Sep 15
1998	Oct 1	Oct 15
1999	Feb 1	Feb 15
1999	Mar 1	Mar 15
1999	Apr 1	Apr 15
1999	Sep 1	Sep 10
1999	Oct 1	Oct 10
1999	Nov 1	Nov 5
2000	Feb 1	Feb 10
2000	Mar 1	Mar 10
2000	Apr 1	Apr 10
2000	May 1	May 8
2000	Oct 1	Oct 10
2000	Nov 1	Nov 10
2000	Dec 1	Dec 8

YEAR	Start Open Season	End Open Season
2001	Feb 1	Feb 10
2001	Mar 1	Mar 10
2001	Apr 1	Apr 10
2001	May 1	May 10
2001	Jun 1	Jun 10
2001	Jul 1	Jul 6
2001	Oct 1	Oct 10
2001	Nov 1	Nov 10
2001	Dec 1	Dec 3
2002	Feb 1	Feb 10
2002	Mar 1	Mar 10
2002	Apr 1	Apr 10
2002	May 1	May 10
2002	Jun 1	Jun 10
2002	Jul 1	Jul 7
2002	Aug 1	Aug 8
2002	Oct 1	Oct 10
2002	Nov 1	Nov 10
2002	Dec 1	Dec 7
2003	Feb 1	Jul 10
2003	Aug 1	Aug 7
2003	Oct 1	Oct 10
2003	Nov 1	Nov 10
2003	Dec 1	Dec 7
2004	Feb 1	Feb 10
2004	Mar 1	Mar 10
2004	Apr 1	Apr 10
2004	May 1	May 10
2004	Jun 1	Jun 10
2004	Jul 1	Jul 10
2004	Aug 1	Aug 11
2004	Oct 1	Oct 11
2004	Nov 1	Nov 10
2004	Dec 1	Dec 10

Table 2. Association coefficients by species for the eastern Gulf of Mexico. Positive numbers indicate a positive correlation between a given species and vermilion snapper.

Coefficient	Common Name	Scientific Name
2.08	PORGY,RED,UNC	*Pagrus pagrus*
2.05	PORGY,WHITEBONE	*Calamus leucosteus*
1.88	TRIGGERFISHES	*Balistidae*
1.75	SCUPS OR PORGIES,UNC	*Sparidae*
1.55	TRIGGERFISH,GRAY	*Balistes capriscus*
1.49	SNAPPERS,UNC	*Lutjanidae*
1.44	BLUE RUNNER	*Caranx crysos*
1.36	HAKE,ATLANTIC,RED & WHITE	*Urophycis*
1.36	JACK,ALMACO	*Seriola rivoliana*
1.28	AMBERJACK,LESSER	*Seriola fasciata*
1.23	PORGY,KNOBBED	*Calamus nodosus*
0.96	PORGY,JOLTHEAD	*Calamus bajonado*
0.94	BANDED RUDDERFISH	*Seriola zonata*
0.82	SCAMP	*Mycteroperca phenax*
0.77	SNAPPER,RED	*Lutjanus campechanus*
0.68	AMBERJACK,GREATER	*Seriola dumerili*
0.60	SNAPPER,LANE	*Lutjanus synagris*
0.47	GROUPER,YELLOWEDGE	*Epinephelus flavolimbatus*
0.42	GROUPER,SNOWY	*Epinephelus niveatus*
0.34	GROUPER,WARSAW	*Epinephelus nigritus*
0.12	KING MACKEREL and CERO	*Scomberomorus*
0.09	DOLPHINFISH	*Coryphaena*
0.08	MARGATE	*Haemulon album*
0.07	GROUPER,BLACK	*Mycteroperca bonaci*
0.03	COBIA	*Rachycentron canadum*
-0.11	HIND,SPECKLED	*Epinephelus drummondhayi*
-0.13	GROUPER,GAG	*Mycteroperca microlepis*
-0.14	TILEFISH,BLUELINE	*Caulolatilus microps*
-0.18	SNAPPER,SILK	*Lutjanus vivanus*
-0.21	SNAPPER,MANGROVE	*Lutjanus griseus*
-0.51	GRUNTS	*Haemulidae*
-0.53	GRUNT,WHITE	*Haemulon plumieri*
-0.53	CREVALLE	*Caranx hippos*
-0.65	GRUNT,BLUESTRIPED	*Haemulon sciurus*
-0.79	GROUPER,RED	*Epinephelus morio*
-0.82	SPANISH MACKEREL	*Scomberomorus maculatus*
-0.98	HOGFISH	*Lachnolaimus maximus*
-1.10	SEA BASSE,ATLANTIC,BLACK,UNC	*Centropristis striata*
-1.23	SNAPPER,MUTTON	*Lutjanus analis*
-2.36	SNAPPER,YELLOWTAIL	*Ocyurus chrysurus*

Table 3. Association coefficients by species for the western Gulf of Mexico. Positive numbers indicate a positive correlation between a given species and vermilion snapper.

Coefficient	Common Name	Scientific Name
1.22	TRIGGERFISH,GRAY	*Balistes capriscus*
1.15	PORGY,RED,UNC	*Pagrus pagrus*
1.00	AMBERJACK,GREATER	*Seriola dumerili*
0.99	SCAMP	*Mycteroperca phenax*
0.98	PORGY,WHITEBONE	*Calamus leucosteus*
0.83	AMBERJACK,LESSER	*Seriola fasciata*
0.81	BIGEYE SCAD	*Selar crumenophthalmus*
0.80	TRIGGERFISHES	*Balistidae*
0.79	SNAPPERS,UNC	*Lutjanidae*
0.78	TILEFISH,BLUELINE	*Caulolatilus microps*
0.78	GROUPER,WARSAW	*Epinephelus nigritus*
0.76	JACK,BAR	*Caranx ruber*
0.75	BLUE RUNNER	*Caranx crysos*
0.62	HIND,RED	*Epinephelus guttatus*
0.58	JACK,ALMACO	*Seriola rivoliana*
0.48	GROUPER,YELLOWFIN	*Mycteroperca venenosa*
0.40	SNAPPER,RED	*Lutjanus campechanus*
0.33	SNAPPER,BLACK	*Apsilus dentatus*
0.28	GROUPER,BLACK	*Mycteroperca bonaci*
0.26	GROUPER,SNOWY	*Epinephelus niveatus*
0.23	SNAPPER,QUEEN	*Etelis oculatus*
0.23	HIND,SPECKLED	*Epinephelus drummondhayi*
0.22	TUNA,YELLOWFIN	*Thunnus albacares*
0.20	DOLPHINFISH	*Coryphaena*
0.18	GROUPER,YELLOWEDGE	*Epinephelus flavolimbatus*
0.17	CROAKER,ATLANTIC,UNC	*Micropogonias undulatus*
0.17	SNAPPER,LANE	*Lutjanus synagris*
0.11	WAHOO	*Acanthocybium solandri*
0.00	COBIA	*Rachycentron canadum*
0.00	SNAPPER,BLACKFIN	*Lutjanus buccanella*
-0.03	HAKE,ATLANTIC,RED & WHITE	*Urophycis*
-0.03	TILEFISH	*Lopholatilus chamaeleonticeps*
-0.11	SNAPPER,SILK	*Lutjanus vivanus*
-0.12	BLUEFISH	*Pomatomus saltatrix*
-0.12	TUNA,BLACKFIN	*Thunnus atlanticus*
-0.17	EELS,CUSK	*Ophidiidae*
-0.22	GROUPER,MARBLED	*Epinephelus inermis*
-0.30	GROUPER,GAG	*Mycteroperca microlepis*
-0.38	SEA TROUT,WHITE	*Cynoscion arenarius*
-0.52	KING MACKEREL and CERO	*Scomberomorus*
-0.87	SNAPPER,MANGROVE	*Lutjanus griseus*
-1.52	SPANISH MACKEREL	*Scomberomorus maculatus*

Table 4. Linear regression statistics for the final GLM models on proportion positive trips (A) and (B) catch rates on positive trips (Gulfwide: Species Composition approach).

A)

LR Statistics For Type 3 Analysis

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	0.27	188.12	<.0001
hooks_per_line	2	8.22	428.88	<.0001
ZONE	3	3.23	894.14	<.0001
rs_season	1	1.52	530.77	<.0001
ZONE*hooks_per_line	6	1.08	442.42	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	0.36	214.71	<.0001
hooks_per_line	2	17.17	531.59	<.0001
rs_season	1	6.94	1964.87	<.0001
ZONE	3	5.47	770.29	<.0001
ZONE*hooks_per_line	6	4.53	1062.13	<.0001
rs_season*hooks_per_	2	1.48	455.00	<.0001

Table 5. Linear regression statistics for the final GLM models on proportion positive trips (A) and (B) catch rates on positive trips (Gulfwide: Gear Configuration approach).

A)

LR Statistics For Type 3 Analysis

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	0.27	621.03	<.0001
hooks_per_line	2	23.27	849.54	<.0001
ZONE	3	8.52	3848.66	<.0001
PERMIT	2	1.90	2544.43	<.0001
ZONE*hooks_per_line	6	1.44	1552.42	<.0001
YEAR*ZONE	33	1.06	1294.98	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	0.23	221.63	<.0001
hooks_per_line	2	16.37	490.24	<.0001
ZONE	3	4.66	1111.91	<.0001
rs_season	1	5.02	2257.13	<.0001
ZONE*hooks_per_line	6	5.67	1696.92	<.0001
rs_season*hooks_per_line	2	1.46	608.07	<.0001

Table 6. Gulf wide nominal CPUE, proportion positive trips (PPT) and index results.

A) Species Composition Approach:

YEAR	Nominal CPUE	PPT	Obs	Positive Trips	Rel. Index	LCI	UCI	CV Index
1993	0.436	0.731	2584	1888	1.219	1.081	1.375	0.060
1994	0.568	0.773	2861	2211	1.314	1.170	1.476	0.058
1995	0.371	0.738	2340	1728	1.014	0.895	1.150	0.063
1996	0.326	0.740	3565	2638	0.938	0.833	1.056	0.059
1997	0.303	0.733	3698	2711	1.009	0.896	1.137	0.060
1998	0.319	0.720	3449	2485	0.945	0.834	1.070	0.062
1999	0.301	0.744	3717	2767	0.899	0.796	1.014	0.061
2000	0.232	0.695	3324	2309	0.689	0.605	0.786	0.066
2001	0.321	0.732	3481	2549	0.835	0.740	0.942	0.060
2002	0.366	0.747	3973	2966	0.943	0.840	1.058	0.058
2003	0.355	0.783	4248	3328	1.068	0.957	1.191	0.055
2004	0.363	0.782	3698	2891	1.127	1.008	1.260	0.056

B) Gear Configuration Approach:

YEAR	Nominal CPUE	PPT	Obs	Positive Trips	Rel. Index	LCI	UCI	CV Index
1993	0.192	0.254	10481	2667	1.449	1.156	1.818	0.113
1994	0.217	0.266	11371	3022	1.427	1.145	1.778	0.110
1995	0.128	0.221	10824	2391	1.092	0.846	1.409	0.128
1996	0.166	0.299	12014	3594	1.133	0.900	1.428	0.116
1997	0.145	0.294	12605	3707	1.196	0.950	1.506	0.116
1998	0.127	0.269	13078	3513	0.797	0.605	1.052	0.139
1999	0.155	0.282	13660	3847	0.834	0.638	1.090	0.135
2000	0.106	0.236	13805	3264	0.614	0.457	0.825	0.148
2001	0.125	0.252	13525	3408	0.712	0.537	0.942	0.141
2002	0.147	0.278	13735	3821	0.792	0.604	1.038	0.136
2003	0.161	0.303	13808	4180	0.969	0.750	1.251	0.128
2004	0.151	0.301	12749	3841	0.986	0.764	1.271	0.128

Table 7. Linear regression statistics for the final GLM models on proportion positive trips (A) and (B) catch rates on positive trips (EASTERN: Species Composition approach).

A)

LR Statistics For Type 3 Analysis

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	0.16	101.86	<.0001
hooks_per_line	2	16.36	3436.63	<.0001
ZONE	1	2.45	525.23	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	0.35	180.84	<.0001
hooks_per_line	2	36.25	5739.24	<.0001
ZONE	1	3.48	595.52	<.0001
rs_season	1	3.40	711.34	<.0001
rs_season*hooks_per_	2	1.63	263.45	<.0001

Table 8. Linear regression statistics for the final GLM models on proportion positive trips (A) and (B) catch rates on positive trips (EASTERN: Gear Configuration approach).

A)

LR Statistics For Type 3 Analysis

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	0.18	1798.57	<.0001
hooks_per_line	2	22.42	9335.57	<.0001
ZONE	1	11.39	6815.59	<.0001
PERMIT	2	2.65	2045.64	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	0.27	203.10	<.0001
hooks_per_line	2	32.20	6437.08	<.0001
ZONE	1	3.55	827.86	<.0001
rs_season	1	2.16	756.82	<.0001
rs_season*hooks_per_	2	1.67	373.26	<.0001

Table 9. Eastern Gulf of Mexico nominal CPUE, proportion positive trips (PPT) and index results.

A) Species Composition Approach:

YEAR	Nominal CPUE	PPT	Obs	Positive Trips	Rel. Index	LCI	UCI	CV Index
1993	0.498	0.731	1491	1090	1.367	1.215	1.538	0.059
1994	0.658	0.765	1788	1368	1.459	1.305	1.630	0.056
1995	0.420	0.740	1460	1080	1.147	1.014	1.296	0.061
1996	0.392	0.735	1947	1431	1.040	0.930	1.164	0.056
1997	0.334	0.695	1716	1193	0.946	0.837	1.070	0.061
1998	0.333	0.697	1646	1147	0.846	0.744	0.960	0.064
1999	0.350	0.743	1930	1434	0.901	0.800	1.014	0.059
2000	0.279	0.698	1699	1186	0.726	0.636	0.828	0.066
2001	0.395	0.704	1835	1292	0.878	0.776	0.992	0.061
2002	0.395	0.716	2147	1538	0.890	0.792	1.000	0.058
2003	0.403	0.750	2288	1716	0.923	0.827	1.031	0.055
2004	0.391	0.739	1920	1418	0.879	0.780	0.989	0.059

B) Gear Configuration Approach:

YEAR	Nominal CPUE	PPT	Obs	Positive Trips	Rel. Index	LCI	UCI	CV Index
1993	0.170	0.197	7835	1546	1.862	1.625	2.134	0.068
1994	0.178	0.204	9333	1902	1.610	1.408	1.841	0.067
1995	0.107	0.164	8909	1464	1.380	1.185	1.608	0.076
1996	0.154	0.221	8802	1942	1.413	1.235	1.617	0.067
1997	0.116	0.190	9059	1725	1.213	1.045	1.409	0.075
1998	0.098	0.182	9424	1713	0.659	0.541	0.802	0.099
1999	0.144	0.203	10218	2078	0.771	0.646	0.919	0.088
2000	0.086	0.165	10456	1730	0.549	0.447	0.674	0.103
2001	0.104	0.174	10367	1808	0.611	0.501	0.744	0.099
2002	0.117	0.196	10534	2063	0.629	0.521	0.758	0.094
2003	0.130	0.209	10484	2192	0.694	0.578	0.832	0.091
2004	0.111	0.206	9408	1942	0.610	0.504	0.739	0.096

Table 10. Linear regression statistics for the final GLM models on proportion positive trips (A) and (B) catch rates on positive trips (WESTERN: Species Composition approach).

A)

LR Statistics For Type 3 Analysis

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	0.69	255.53	<.0001
PERMIT	2	3.59	447.14	<.0001
rs_season	1	2.02	526.11	<.0001
ZONE	1	1.91	349.32	<.0001
hooks_per_line	2	1.34	258.92	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	0.88	159.20	<.0001
rs_season	1	7.26	1518.95	<.0001
ZONE	1	7.77	1078.31	<.0001
hooks_per_line	2	1.54	228.36	<.0001

Table 11. Linear regression statistics for the final GLM models on proportion positive trips (A) and (B) catch rates on positive trips (WESTERN: Gear Configuration approach).

A)

LR Statistics For Type 3 Analysis

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	0.61	371.79	<.0001
hooks_per_line	2	9.56	2156.21	<.0001
PERMIT	2	2.79	1193.82	<.0001
rs_season	1	2.10	1081.38	<.0001
ZONE	1	1.36	593.80	<.0001

B)

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	0.59	137.47	<.0001
rs_season	1	6.32	1589.21	<.0001
ZONE	1	7.50	1493.92	<.0001

Table 12. Western Gulf of Mexico nominal CPUE, proportion positive trips (PPT) and index results.

A) Species Composition Approach:

YEAR	Nominal CPUE	PPT	Obs	Positive Trips	Rel. Index	LCI	UCI	CV Index
1993	0.353	0.730	1093	798	0.974	0.847	1.121	0.070
1994	0.418	0.786	1073	843	1.088	0.953	1.243	0.066
1995	0.290	0.736	880	648	0.837	0.715	0.980	0.079
1996	0.246	0.746	1618	1207	0.813	0.719	0.918	0.061
1997	0.276	0.766	1982	1518	1.074	0.963	1.199	0.055
1998	0.306	0.742	1803	1338	1.074	0.956	1.206	0.058
1999	0.249	0.746	1787	1333	0.937	0.834	1.053	0.058
2000	0.182	0.691	1625	1123	0.642	0.564	0.732	0.065
2001	0.238	0.764	1646	1257	0.794	0.707	0.893	0.058
2002	0.332	0.782	1826	1428	1.032	0.930	1.145	0.052
2003	0.298	0.822	1960	1612	1.266	1.152	1.393	0.047
2004	0.332	0.828	1778	1473	1.467	1.331	1.616	0.048

B) Gear Configuration Approach:

YEAR	Nominal CPUE	PPT	Obs	Positive Trips	Rel. Index	LCI	UCI	CV Index
1993	0.255	0.424	2646	1121	0.942	0.803	1.105	0.080
1994	0.392	0.550	2038	1120	1.108	0.948	1.294	0.078
1995	0.227	0.484	1915	927	0.856	0.714	1.027	0.091
1996	0.200	0.514	3212	1652	0.880	0.766	1.011	0.069
1997	0.219	0.559	3546	1982	1.172	1.035	1.328	0.062
1998	0.203	0.493	3654	1800	0.935	0.817	1.070	0.067
1999	0.186	0.514	3442	1769	0.911	0.797	1.040	0.067
2000	0.170	0.458	3349	1534	0.663	0.573	0.767	0.073
2001	0.191	0.507	3158	1600	0.777	0.675	0.894	0.070
2002	0.248	0.549	3201	1758	1.010	0.890	1.147	0.064
2003	0.258	0.598	3324	1988	1.298	1.160	1.452	0.056
2004	0.266	0.568	3341	1899	1.448	1.290	1.625	0.058

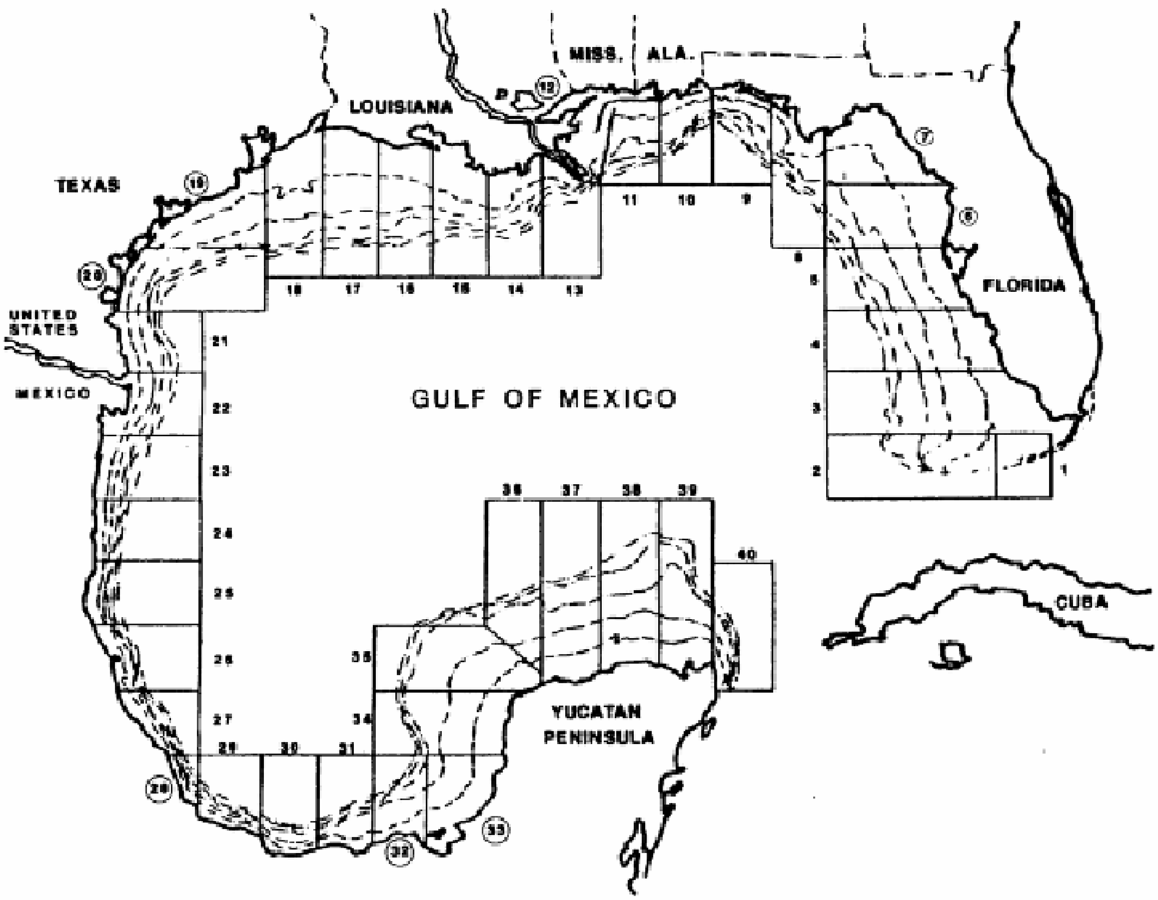

Figure 1. Gulf of Mexico with NMFS statistical grids.

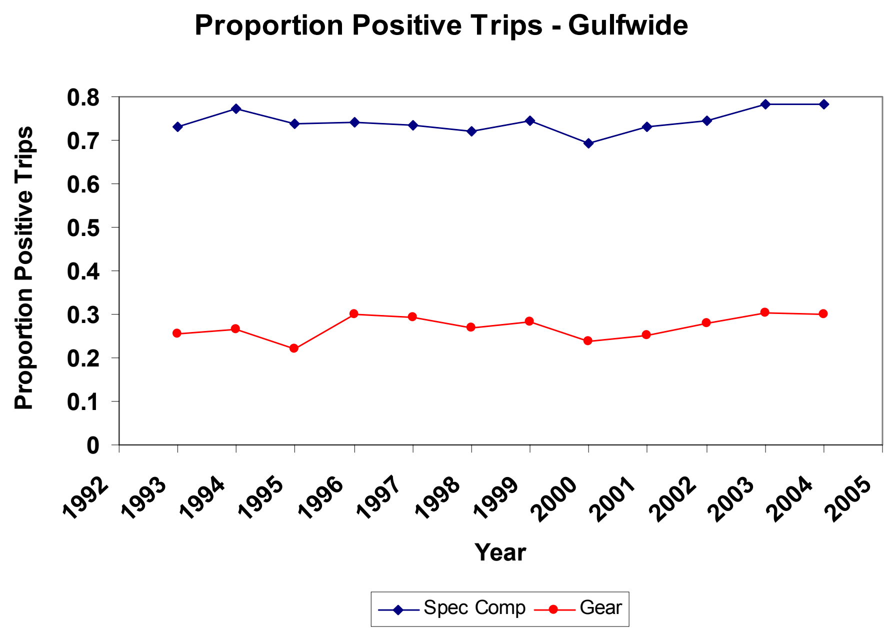

Figure 2. Annual trend in proportion of positive trips for the gulfwide treatments.

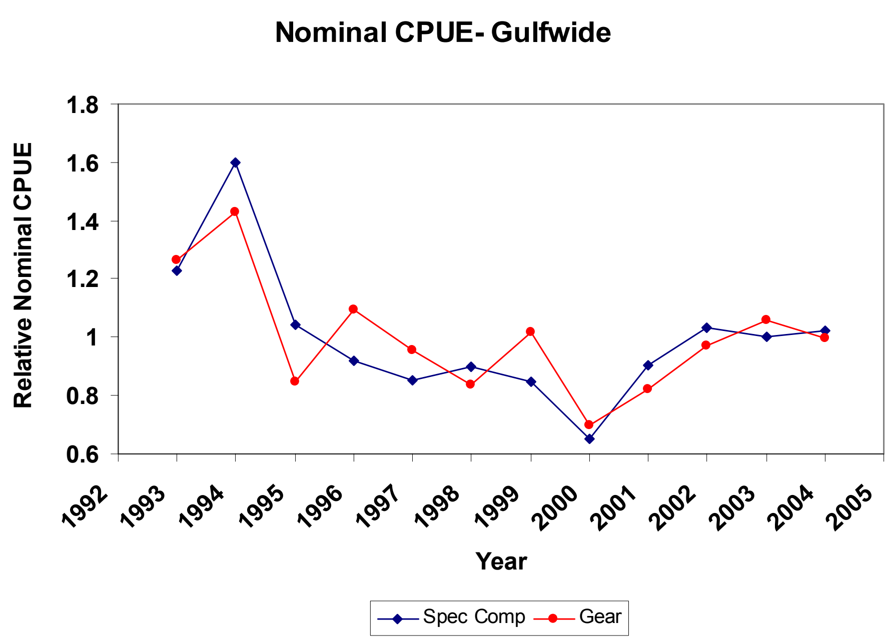

Figure 3. Annual trend in nominal CPUE for the gulfwide treatments.

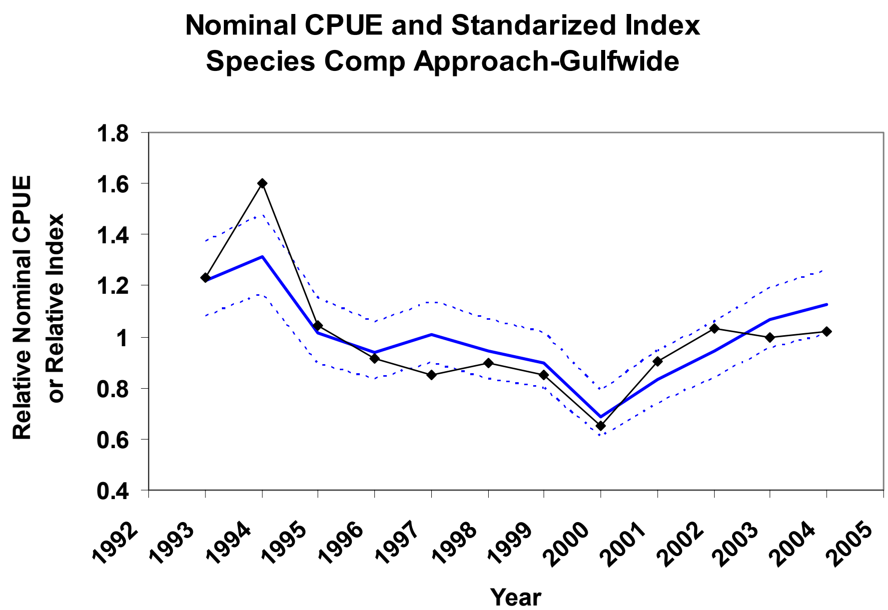

Figure 4. Gulfwide nominal CPUE (light black line with diamonds) and the gulfwide delta-lognormal index (heavy blue line no symbols) constructed using the species composition approach. The dotted lines are the upper and lower 95% confidence intervals.

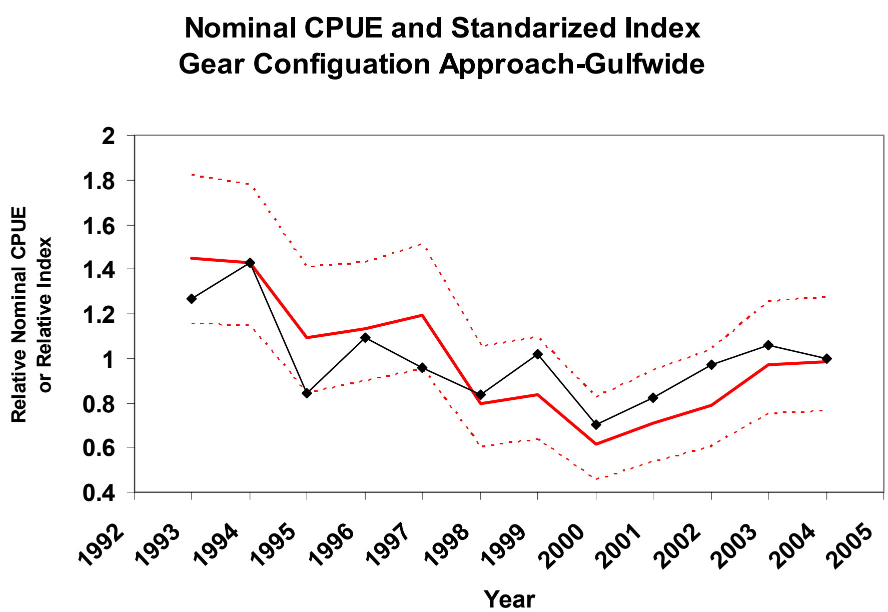

Figure 5. Gulfwide nominal CPUE (light black line with diamonds) and the gulfwide delta-lognormal index (heavy red line no symbols) constructed using the gear configuration approach. The dotted lines are the upper and lower 95% confidence intervals.

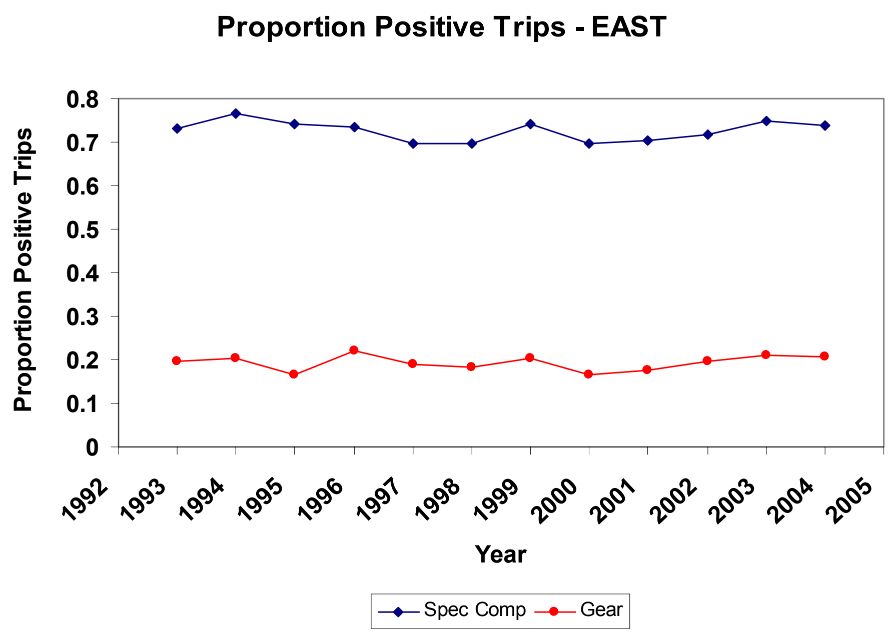

Figure 6. Annual trend in proportion of positive trips for the eastern treatments.

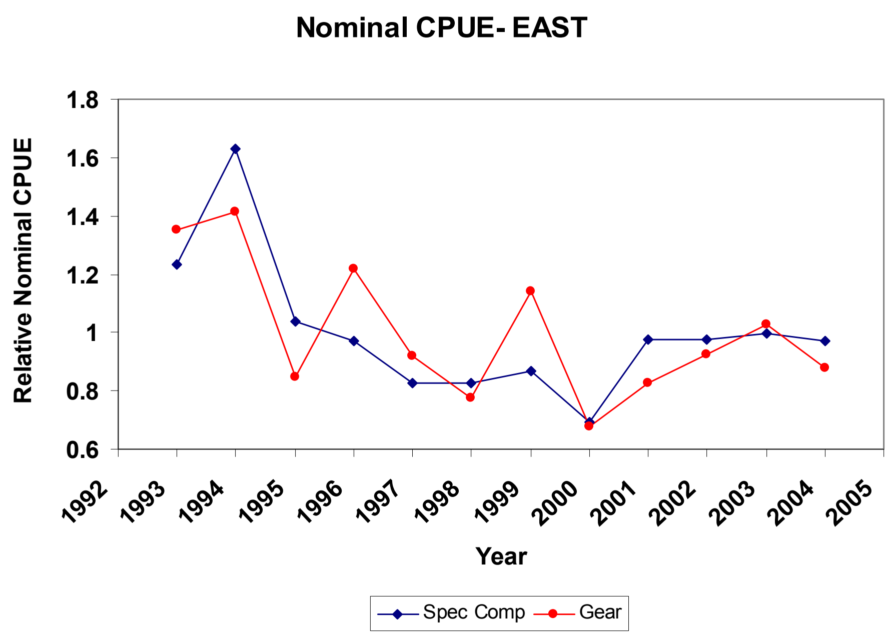

Figure 7. Annual trend in nominal CPUE for the eastern treatments.

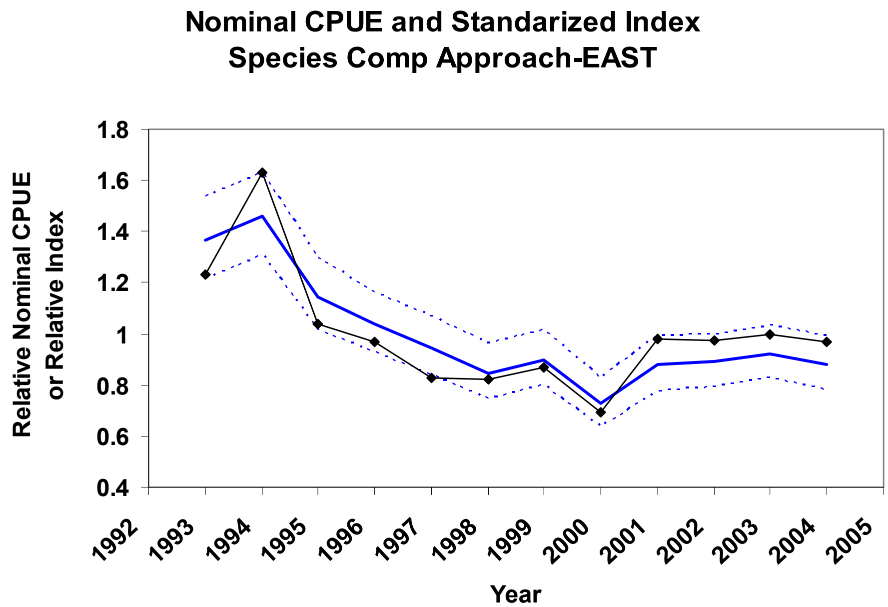

Figure 8. Nominal CPUE (light black line with diamonds) and the delta-lognormal index (heavy blue line no symbols) for the eastern gulf constructed using the species composition approach. The dotted lines are the upper and lower 95% confidence intervals.

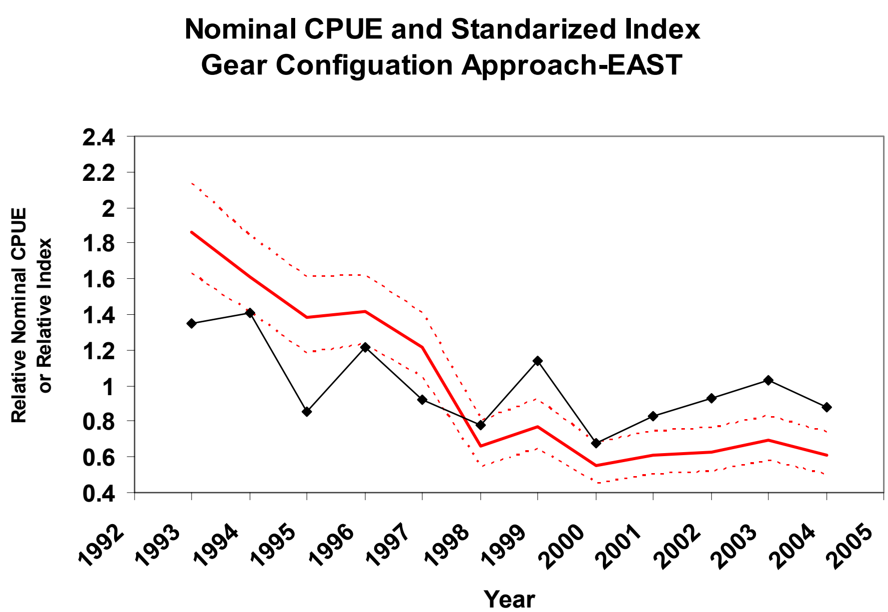

Figure 9. Nominal CPUE (light black line with diamonds) and the delta-lognormal index (heavy red line no symbols) for the eastern gulf constructed using the gear configuration approach. The dotted lines are the upper and lower 95% confidence intervals.

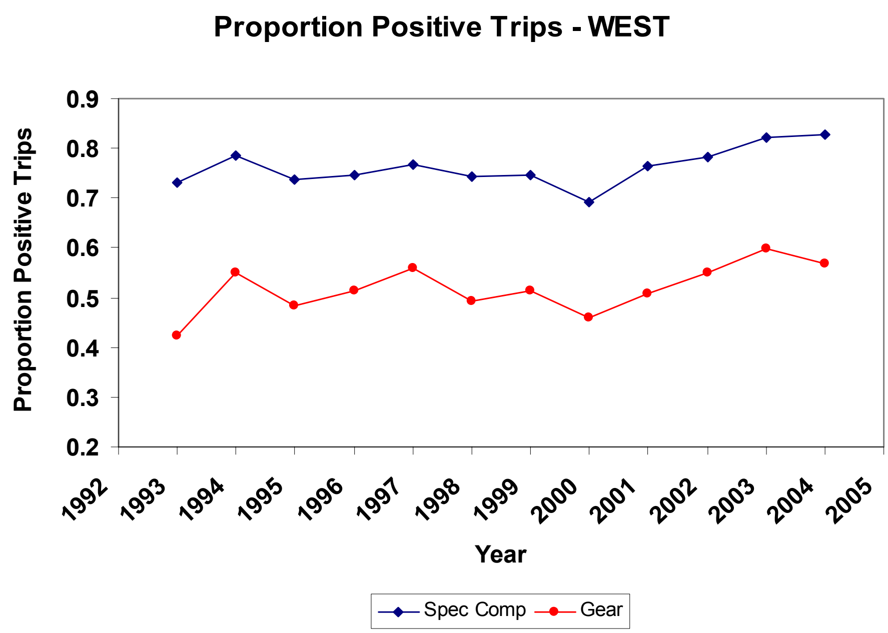

Figure 10. Annual trend in proportion of positive trips for the western treatments.

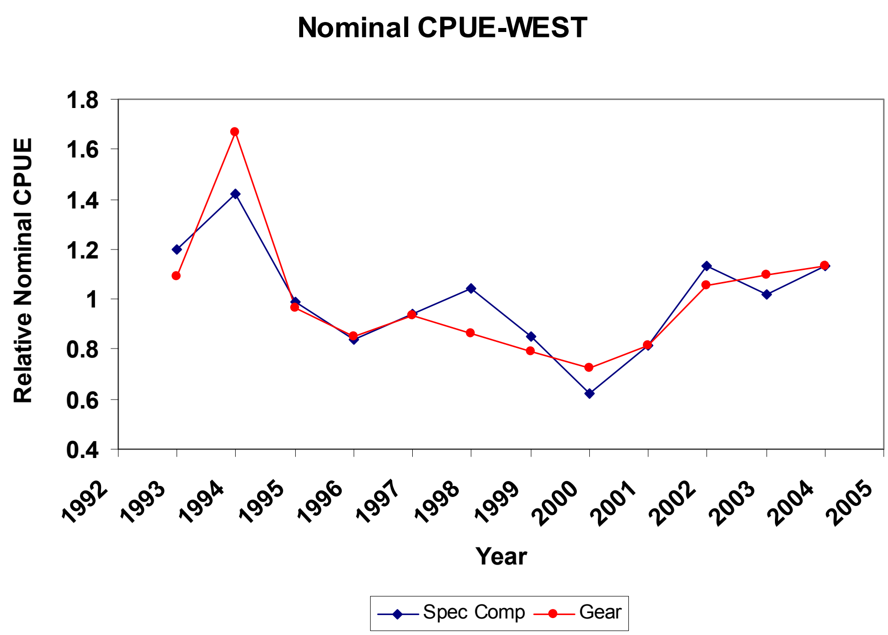

Figure 11. Annual trend in nominal CPUE for the western treatments.

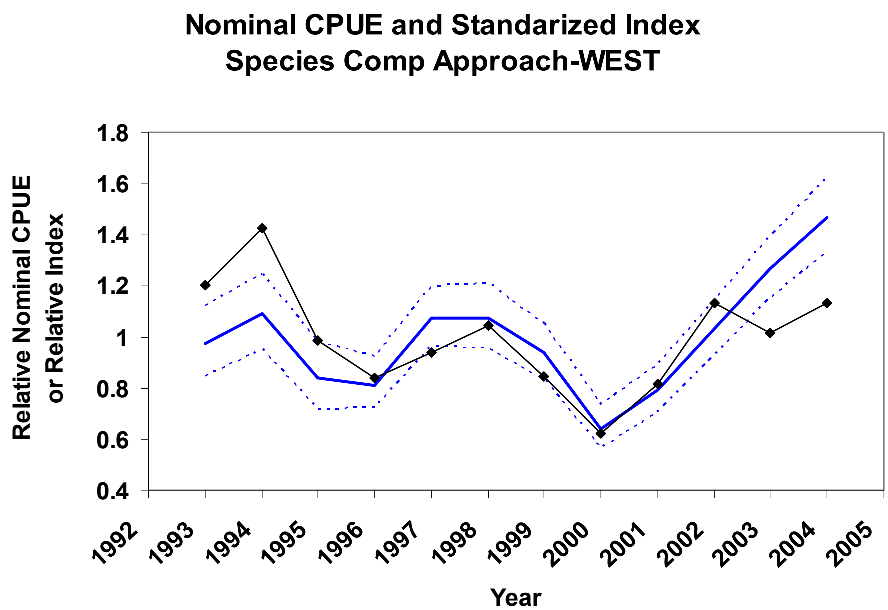

Figure 12. Nominal CPUE (light black line with diamonds) and the delta-lognormal index (heavy blue line no symbols) for the western gulf constructed using the species composition approach. The dotted lines are the upper and lower 95% confidence intervals.

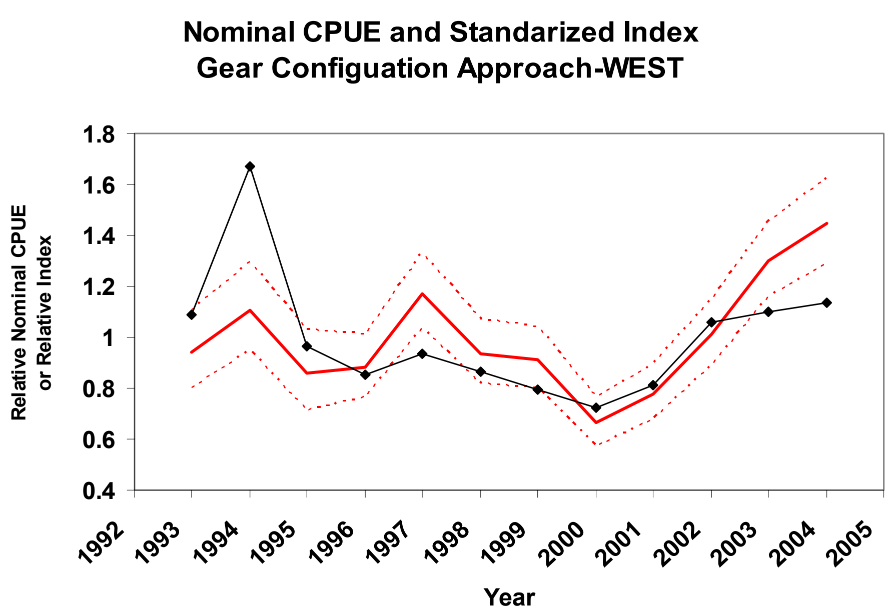

Figure 13. Nominal CPUE (light black line with diamonds) and the delta-lognormal index (heavy red line no symbols) for the western gulf constructed using the gear configuration approach. The dotted lines are the upper and lower 95% confidence intervals.