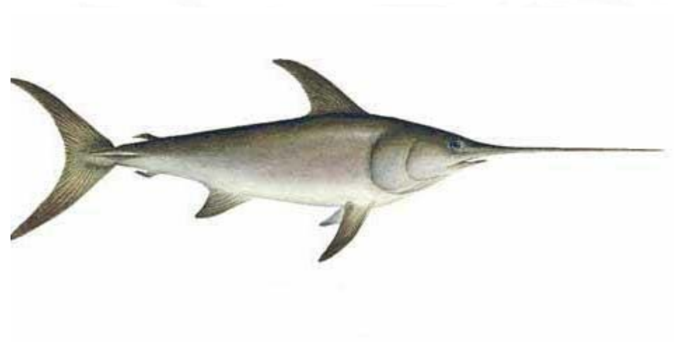
International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean

ISC/09/BILLWG-1/05

Preliminary CPUE Time Series from the California Driftnet Fishery, 1990-Present

Kevin Piner
NOAA National Marine Fisheries Service
Southwest Fisheries Science Center
8604 La Jolla Shores Dr., La Jolla, CA 92307, USA

Amy Betcher
NOAA National Marine Fisheries Service
Southwest Fisheries Science Center
8604 La Jolla Shores Dr., La Jolla, CA 92307, USA



Working document submitted to the ISC Billfish Working Group Workshop, February 3-10, 2009, Honolulu, Hawaii, USA. Document not to be cited without author's written permission.

Preliminary CPUE Time series from the California Driftnet Fishery 1990-Present

Kevin Piner and Amy Betcher
NOAA Fisheries
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, Ca 92037

Abstract

Drift gill net fisheries targeting swordfish have operated off the west coast of the United States since the early 1980's. Management regulations have impacted both the method and area of operation in attempts to reduce impact on non-targeted species. The fishery has been somewhat stable in operations since 1990, with observer coverage starting in that year. A CPUE series was derived from 1990-2008 from logbooks recording catch and effort data. The time series show a flat trend, with increase variance post 2000. Effort directed at swordfish has also decline over the same period and the increasing variance reflects a near linear decline in observations. More work is needed to better understand the affects of regulations on the derived CPUE series. With additional work it may also be possible to extend the time series back to the early 1980's.

Introduction

Overview of gillnet fisheries

Gillnet operations off the coast of California (USA) are comprised of both set-net and drift-net (drift-net) fisheries. Set-nets typically take demersal species in inshore waters while drift-net fisheries capture pelagic species from farther offshore. The drift-net fishery has historically targeted sharks (thresher and mako) and swordfish, but have included other larger species such as opahs and tunas. The fishing vessels typically range in size from 30-75 feet with an increasing trend in size which may be associated with shift in fishing patterns to more offshore banks. Fishing trips have varied in duration from one night to more than a month (Diamond et al. 1986). Market factors, fish holding facilities and weather conditions all impact the duration of fishing activity. The majority of drift-net fishing has taken place in southern and central California; however there has been an expansion of fishing effort as far as the Canadian border.

The drift-net fishing gear is comprised of float line (buoyed) and lead line with mesh panels hanging between. Mesh size has ranged from 13-22 inches stretched, but the average size has been relatively constant (19-22 in) since 1985-1986 (Hanan et al. 1993). Nets are typically between 800-1000fm (a fm=6ft) in length and could be fished near the surface to as deep as 30m by lengthening buoy lines. Fishing normally takes place at night, with nets set before dusk and retrieved by morning.

Management measures affecting fishery

Beginning in 1980, swordfish were first allowed to be landed and sold from the drift-net fishery during a specific portion of the year. However, those landing were assumed to be non-targeted catch. In 1982 direct targeting of swordfish was allowed over part of the year and mesh size was increased to 14 inches, a maximum of 150 permits were issued and time/area closures were used to control marine mammal interactions. In 1984 an additional 35 permits were issued for fishing north of the traditional fishing areas of the southern California bight. In 1985 a requirement of equal shark/swordfish catch was lifted. In 1986 fishing in the northern areas was restricted to outside 12 nm. In 1989 gill net fishing inside 75 nm of the mainland was restricted for May-mid July. In 1990 the

National Marine Fisheries Service began placing observers on vessels to monitor marine mammal interactions (Carretta and Enriquez 2006). In 1997 acoustic devices (pingers) and net extenders (extend the distance of floatline from surface by 11m) became mandatory on nets to reduce mammal bycatch (Carretta et al. 2005). In addition, season/area closures have been instituted after 2000 to reduce turtle encounters.

Objectives

The objectives of this paper are to evaluate important factors affecting drift-net fishery catch and to construct a time series of standardized Catch per Unit Effort (CPUE) from the directed swordfish drft fleet.

Materials and Methods

Data source and fields

Data for this project has come from a mandatory logbooks program which began in 1980 (Huppert and Odemar 1986). Logbook reporting after the first year of implementation has generally been assumed to be good (Miller et al. 1983, Beeson and Hanan 1991) with reported catch of swordfish being 90-120% of the landed level (Hanan et al. 1993). In the first year of the program reporting was low (<10%) due to difficulties in implementing of the program. Information in the logbooks includes, target species, catch by species (landed and released and unknown), vessel identifiers, target species, set number, fishing time and location. All were potential factors to be investigated for inclusion with the CPUE modeling. Only trips targeting swordfish were used in the subsequent analysis. The sampling unit was defined as a net set by a specific vessel on a single night.

Modeling methods and Model selection

A delta approach (Lo et al. 1992; Stefánsson 1996) was used to model CPUE. The proportion of positive observations was modeled using a binomial error assumption and the catch rate of positive observations using the best fitting of several different error distributions (gamma, lognormal etc.) A range of fishing and oceanographic factors were considered for inclusion the model. Evaluation of the importance of factors was based upon explanation of deviance and parameter significance. Factors investigated included season (winter Dec-Feb, Spring Mar-May, Summer June-Aug and Fall Sept-Nov), latitude (2 blocks 30-37^{o}N and >37^{o}N), longitude (4 degree blocks), Gear depth (2 blocks- <15m, >15m), and water depth (10 blocks -0-200m, 200-400m,….>1800m). Effort was calculated as hours the product of the hours fished and net length (fmhrs).Catch is recorded as numbers of fish caught (landed and released)

The final model used to estimate CPUE in both proportion positive and positive catch rate was as follows:

Y_{ijklm}=mean +year$_i$+geardepth$_j$+latitude$_k$+season$_l$+waterdepth$_m$ + Error$_{ijklm}$

The final estimate of the annual abundance index was the product of the back transformed marginal year effects (Searle 1980), corrected for the log bias in the lognormal back transformation. The variance estimates were obtained by jackknifing the data (Dick pers comm.).

Results and Discussion

Data characteristics

The driftnet fishery has operated across the entire length of the US west coast (Figure 1). Although data existed from 1981-2008 we did not use data from the 1980's because of the rapidly changing regulations on the developing fishery. The most notable changes included mesh size (before 1986) and the area opening/restrictions of the late 1980's. In addition we restricted the data to only those observations above 30^{o}N because of a lack of positive observations below 30^{o}N (Figure 2). Sample size was much larger in the early part of the time series (Table 1) as effort has decline nearly linearly until present.

All factors investigated were found to be important in the estimation of CPUE ($p<.01$), however we felt that longitude and water depth were equivalent observations of the same process, thus we only use the water depth in the final model. It was our belief that longitude is an imprecise measure of distance from shore and water depth, thus the observed water depth was a preferable measure of the environment. The fishery is predominantly a Fall and Winter fishery, but there appears to be little change in the distribution of CPUE by season (Figure 3). Catch rates are generally higher in shallower water depths (~500m) in all seasons, however there appears to be a trend of higher catch rates in the most northerly latitudes at deeper depths (Figure 4). This could be due to regulation and may indicate an interaction term between depth and latitude might be significant. However no interactions were used as the fishery appears relatively static with respect to all factors investigated. In addition, the lognormal error distribution of the positive catch rates held significantly more AIC weight than alternative models and thus was chosen as the distribution to model the positive catch rates.

Regression results and diagnostics

The time series of CPUE was relatively flat over the series (Figure 5) with increased uncertainty in the last years due to diminishing effort (Table 2). Estimated CV's are twice as large after 2000 due to reduced sample size (Table 1). Use of a statistical model, as well as sub-settting the data to remove missing values did not greatly change the results from the nominal values (Figure 6). The greater inter-annual variability of the standardized estimates may be attributed to the data sub-setting. Model diagnostics indicated reasonable performance of the lognormal model (Figure 7) even though the observed data themselves were somewhat noisy (Figure 8). Although, AIC criteria strongly favored the lognormal model for estimating catch rates, the estimates of CPUE from alternative error assumptions were generally quite similar with alternative error assumptions (Figure 9).

General discussion

Increasing uses of time/area closures as well as unknown consequences of pingers and nest extenders cause some concern about the constancy of the catchability assumption after 1997. It is unclear if the increase variability in CPUE after 1997 is due to management measures or declining effort. We note that catch rates are generally higher in the southern area and the effect of the more recent time/area closures appears to be to shift increased fishing effort southward. In contrast, the unusually high estimate of CPUE in 2001 (relative to nominal) may be due to some of the closure moving effort out of an unproductive area. The estimated CV is also quite large indicating that the estimate is uncertain. More investigation is warranted.

A future analysis should more carefully consider how to explicitly deal with the effects of time/area closures. A first analysis may be to simply an area that has not been affected by regulation and estimate CPUE for this restrict set. The tradeoff of this approach is the reduction in both sample size and spatial extent of the data. A more complex method to deal with time/area closures may allow the use of the full time data set and may allow the extension of the time series back to 1986. To extend the time series back to the start of the data (1981), it will also be necessary to quantify the effects of mesh size on catch rate of swordfish. There is some data on mesh size in the current logbook, so it may be feasible to understand this process and use all available years. An additional improvement will be to treat sets from the same vessel/day as replicate observations of the CPUE of the vessel instead of independent observations of the population catch rate. This is unlikely to change the estimated time series, but may affect the estimates of variance due to a reduction in sample size and reduction in correlation between some observations.

Literature cited

Beeson, M., and D. Hanan. (1991). Effort estimates of California gill net fisheries: halibut-angel shark set net and shark-swordfish drift net for 1990-1991 fishing year. Final Rep. NA90AA-HFC401.

Caretta, J.V., and L. Enriquez (2006). Marine Mammal bycatch and estimated mortality in California commercial fisheries during 2005. NOAA/NMFS Admin Rept LJ-06-07. 14p.

Carretta, J.V., T. Price, D., Petersen, and R. Read (2005) Estimates of marine mammal, sea turtle, and seabird mortality in the California drift gillnet fishery for swordfish and thresher shark, 1996-2002. Mar. Fish Rev. (66) 21-31

Diamond, S.L., D.A., Hanan, and J.P., Scholl (1986) Drift gill net observations for the 1984-1985 fishing season. NOAA/NMFS SWFSC Admin Rep. LJ-86-25C.

Hanan, D.A., D.B., Holts and A.L., Coan Jr. (1993). The California drift gill net fishery for sharks and swordfish, 1981-1982-1990-1991. Cal. Dept. Fish and Game Bull. (175) 95p.

Huppert, D.D., and M. Odemar. (1986). A review of California limited entry programs. N. Mollet Ed. Fishery Access control programs worldwide: proceedings of the workshop on management options for the north Pacific longline fisheries. Alaska Sea Grant Rep. 86-4.

Lo, N.C.H., L.D., Jacobson, J.L. Squire. (1992) Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49(12):2515-2526.

Miller, D.J., M.J., Herder, and J.P. Scholl. (1983) California marine mammal-fishery interactions study, 1979-1981. NOAA/NMFS SWFSC Admin Rep. LJ-83-13C 233p.

Searle, S.R. (1980) Population marginal means in the linear model: an alternative to least squares means. Am. Stat. 34(4):216-221.

Stefánsson, G. (1996) Analysis of groundfish survey abundance data: combining the GLM and delta approaches. ICES J. Mar. Sci. 53:577-588.

Table 1. General statistics of the CPUE data used in this work.

year	[illegible]	Mean	Std	Minimum	Maximum
1990	3948	0.00022	0.00030	0.00000	0.00282
1991	4005	0.00017	0.00026	0.00000	0.00322
1992	3599	0.00026	0.00035	0.00000	0.00383
1993	4853	0.00025	0.00300	0.00000	0.20370
1994	3956	0.00013	0.00017	0.00000	0.00220
1995	3200	0.00021	0.00032	0.00000	0.00750
1996	2806	0.00019	0.00026	0.00000	0.00288
1997	2442	0.00025	0.00038	0.00000	0.01000
1998	2502	0.00023	0.00028	0.00000	0.00200
1999	2367	0.00020	0.00024	0.00000	0.00230
2000	1067	0.00019	0.00027	0.00000	0.00188
2001	1276	0.00015	0.00028	0.00000	0.00511
2002	1290	0.00014	0.00023	0.00000	0.00220
2003	1076	0.00012	0.00019	0.00000	0.00242
2004	842	0.00035	0.00222	0.00000	0.06349
2005	791	0.00030	0.00118	0.00000	0.03030
2006	1256	0.00041	0.00064	0.00000	0.01222
2007	1084	0.00049	0.00273	0.00000	0.06944
2008	48	0.00011	0.00023	0.00000	0.00083

Table 2. Estimated CPUE and CV.

year	●. ^	CV
1990	0.000137	0.16026
1991	5.23E-05	0.222995
1992	9.70E-05	0.203622
1993	9.02E-05	0.185184
1994	6.28E-05	0.20694
1995	0.000106	0.167192
1996	8.50E-05	0.226553
1997	0.000141	0.319123
1998	2.52E-05	N/A[1]
1999	0.000105	0.321283
2000	4.02E-05	0.419695
2001	0.000272	1.088563
2002	8.46E-06	0.16026
2003	N/A	N/A
2004	N/A	N/A
2005	0.000106	N/A
2006	0.000359	0.119098
2007	0.000207	0.182196
2008	7.80E-05	0.501261

[1]N/A- indicates incomplete data for analysis

Data Investigation

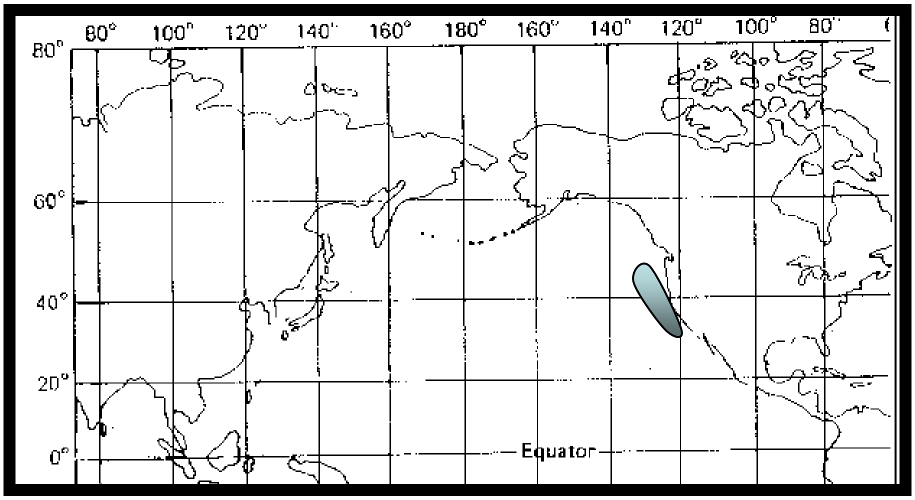


Figure 2. Spatial distribution of fishery data in relation to the north Pacific ocean.

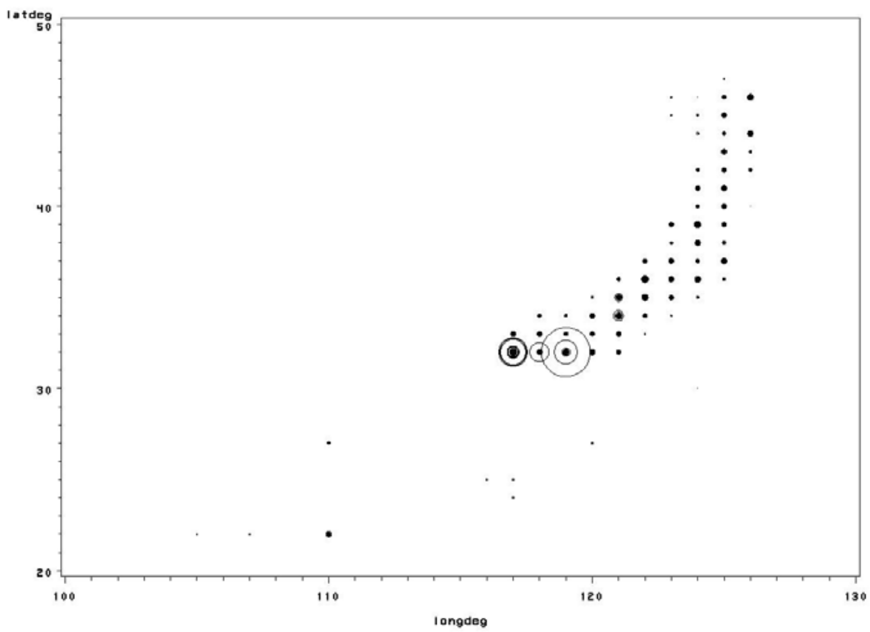


Figure 2. Bubble plot of CPUE (1990-2008) by latitude and longitude (degrees). The size of the bubble indicates the magnitude of the CPUE.

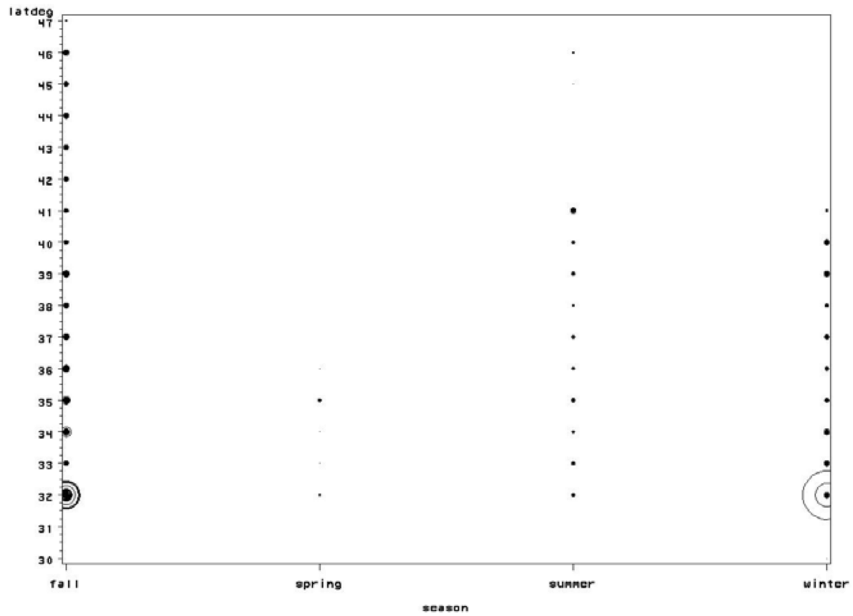


Figure 3. Bubble plot of CPUE (1990-2008) by latitude and season. The size of the bubble indicates the magnitude of the CPUE.

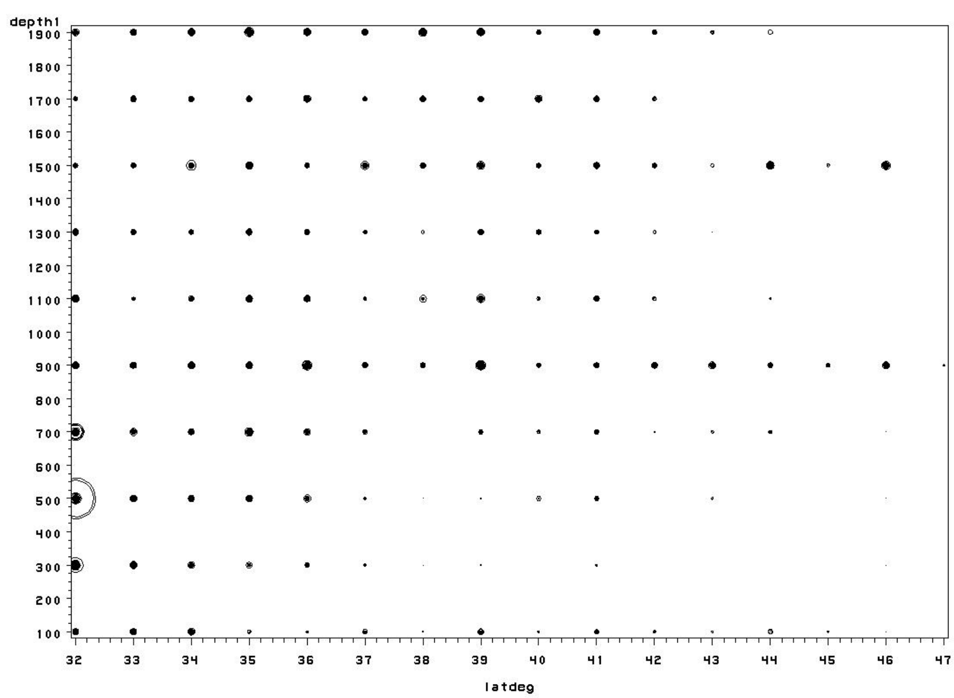


Figure 4. Bubble plot of CPUE (1990-2008) by depth bin and latitude. The size of the bubble indicates the magnitude of the CPUE.

Model Results

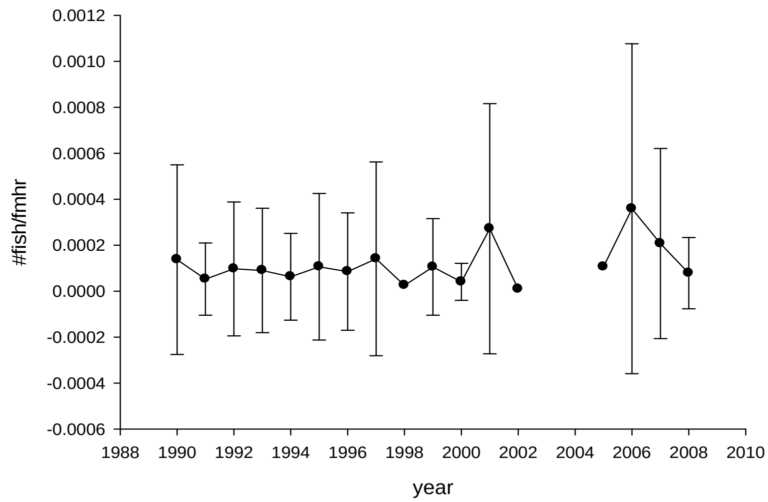


Figure 5. Yearly estimates of CPUE (#swordfish/fmhrs) and associated SE.

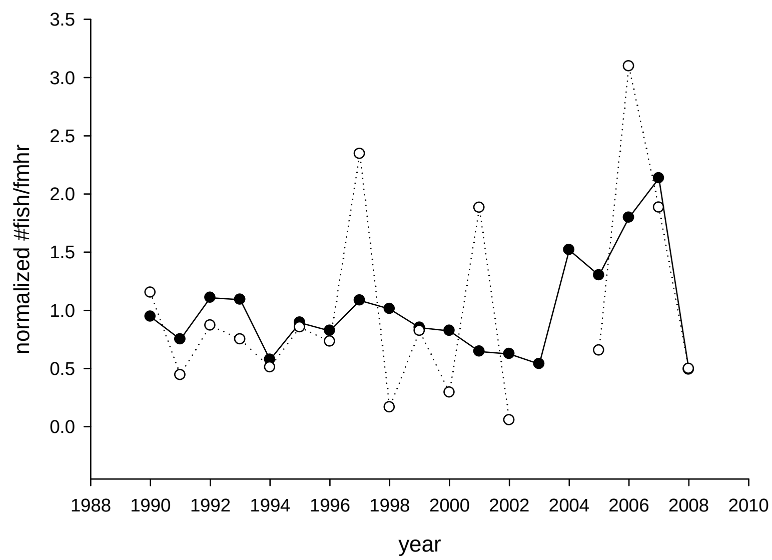


Figure 6. Yearly estimates of CPUE (#swordfish/fmhrs) from both nominal and model estimates. Estimates have been normalized by the mean of each series. Nominal estimates are given by a solid line and model estimates by the dotted line.

Model Diagnostics

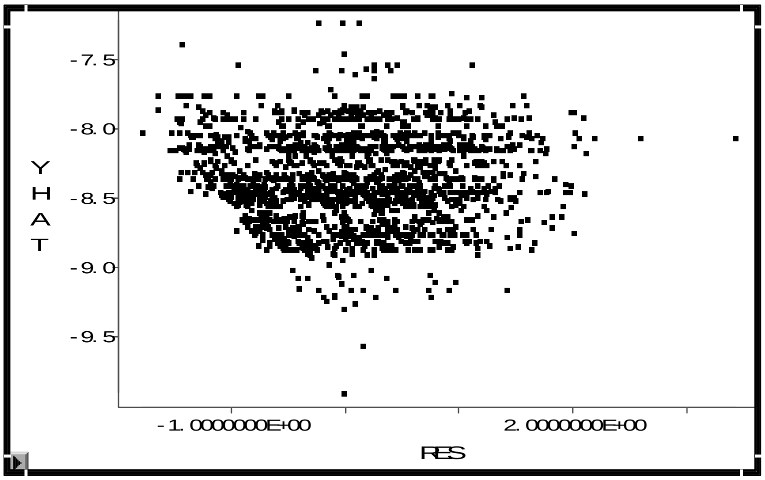


Figure 7. Plot of predicated and residual of the positive catch rate model.

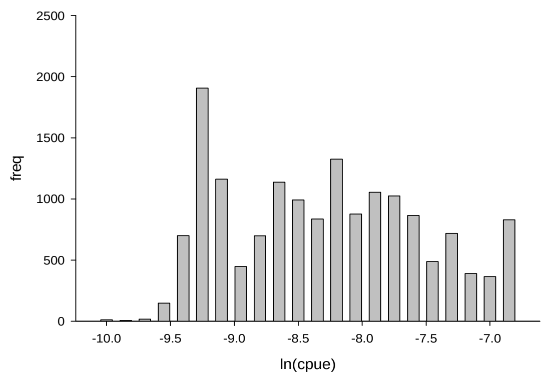


Figure 8. The frequency of ln(CPUE) for discreet bins..

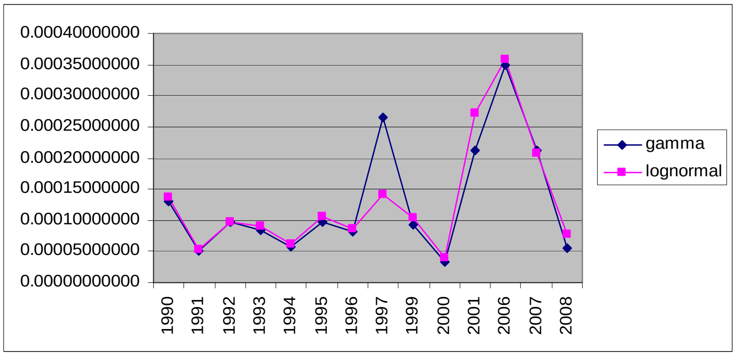


Figure 9. Plot estimated CPUE for the lognormal and an alternate error assumption (gamma).