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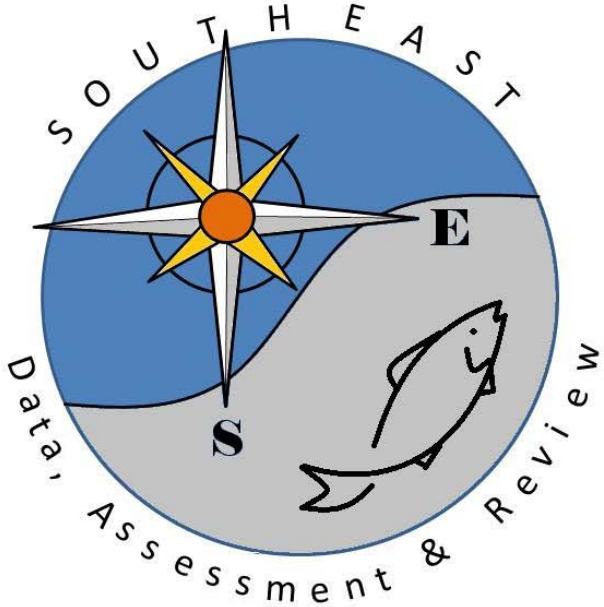

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Introduction

Juvenile red snapper (*Lutjanus campechanus*) are frequently caught by shrimp trawlers targeting brown shrimp, *Penaeus aztecus*, or pink shrimp, *P. duorarum,* in offshore areas of the Gulf of Mexico (Bradley and Bryan 1975). Nichols (2004) has estimated the total bycatch of red snapper since 1972 based on effort and bycatch per unit effort statistics gathered by the NMFS. Unfortunately, this time series cannot be extended further back in time for lack of reliable bycatch per unit effort statistics. Moreover, complete effort data are lacking prior to 1960 (J. Nance, pers. comm.). Nevertheless, there was a strong recommendation made during the last SEDAR workshop to extend this time series as far back as possible in order to give the stock assessment models a better frame of reference for estimating benchmark statistics relevant to management. In particular, it was suggested that an approximation for the effort trends prior to 1960 could be gleaned from backward extrapolations of a linear regression of effort against year for the period 1960-70. The results of such an exercise are shown in Figure 1. The extrapolations for the areas west of the Mississippi river imply that the offshore fishery began in about 1950, but the extrapolations for the east would seem to indicate that the effort in 1950 was nearly the same as in 1960. While these extrapolations may not be too far off the mark, they are certainly arbitrary and do not reflect the rapid build up in the fishery indicated by a number of historical references. This paper examines several such historical references and develops a index of effort that should more accurately represent the historical trends of the offshore shrimp fishery. It then develops estimates of bycatch based on the suggestions made during the SEDAR workshop.

A brief history of offshore shrimping in the Gulf of Mexico

The first known case where a vessel landed a catch consisting almost entirely of brown shrimp occurred in Texas during the year 1940, however notable catches of brown shrimp did not occur until 1947 when, in the face of a declining white shrimp fishery, several vessels began targeting brown shrimp in deeper water off the Texas coast (Lyles 1951). Initially, brown shrimp did not sell very well, but by 1948 a market was developed and the landings of brown shrimp in Texas increased substantially. Large populations of pink shrimp were also discovered in Florida waters off the Dry Tortugas late in 1949 and by 1950 there was a substantial fishery there as well (Idyll 1957; Joyce and Eldred 1966). In the fall of 1950, large concentrations of brown shrimp were found off the Mississippi Delta in depths of 50 to 100 meters and, by 1951, many trawlers were observed working that area (Springer 1951).

The development of the aforementioned fisheries created a demand for larger, more powerful vessels that could operate efficiently in the deeper offshore areas. This spurred a construction boom producing an average of 325 shrimp trawlers per year for the 1949-53 period and 432 in 1954. After that the construction of new trawlers declined from 168 vessels in 1955 to “almost zero” in 1961 (Captiva 1966). Interestingly, these statistics match up well with the growth in the number of shrimp otter-trawl vessels (boats greater than 5 tons) listed in the operating units section of the Fishery

Statistics of the United States[1] (Figure 2). Inasmuch as most of the white shrimp grounds were already over-capitalized (Springer 1951, Lyles, 1951) and few of the vessels built prior to 1950 were adequately equipped to trawl in the deeper offshore waters (Springer 1951), it is reasonable to assume that the statistics on new trawl "vessels" grossly reflects the effort being expended in pursuit of brown and pink shrimp in the offshore areas. Some further justification for this assumption can be found in the rather close agreement between the number of offshore trawlers operating on the Tortugas grounds (the most important offshore grounds in Florida) and the increase in shrimp trawl vessels recorded in the operating units record for Florida during the same period (Figure 3).

The effort expended on the offshore grounds seems to have leveled off during the early sixties when few boats were built. However, another surge in vessel construction began in late 1963 in response to increasing market demand (Captiva 1966). This second boom is evident both in the number of days fished[2] and the number of shrimp trawl vessels (Table 1).

Reconstruction of 'prehistoric' bycatch and effort

In consideration of the above historical account, it appears that the number of shrimp trawl vessels recorded in the operating units data base may be a useful measure of the relative effort exerted by the fleet prior to 1960. Assuming most of the older vessels were not well suited to trawling the deeper offshore waters, we index the amount of offshore effort by the number of shrimp trawl vessels added to the record since 1947 in Texas, 1949 in Florida, and 1950 in the remaining states.

The two time series of vessel operating units (O) were rescaled to days fished (D) by use of the scalars p that minimized

$$(1) \qquad \sum_{i=1960}^{1970} \left(D_{i,west} - p_{west} O_{i,west} \right)^2 + \left(D_{i,east} - p_{east} O_{i,east} \right)^2$$

The rescaled series are shown in Figure 4 and Table 2. It is evident that the trends in number of new vessels are quite similar to the trends in effort units for the period 1960-1970, when both types of data are available. Moreover, the trends prior to 1960 agree qualitatively with the historical counts of a rapidly developing fishery that began to level out during the late 1950's. Hence we conclude that the reconstructed time series are reasonably accurate representations of the actual effort trends.

Reconstructing the trends in bycatch is more problematic than reconstructing effort, and there are little data with which to verify whether or not the estimated trends are correct, even in a qualitative sense. One approach is to multiply the reconstructed effort data by catch per unit

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[1]Fishery Statistics of the United States (1948-1970). U.S. Government printing office, Washington D. C. Produced by the U. S. Fish and Wildlife Service (Bureau of Commercial Fisheries) branch of the U. S. Dept. of the Interior until 1968, then the National Marine Fisheries Service brach of the U.S. Dept. of Commerce).

[2]Number of 24 hour days fished provided by J. Nance, Chief, Fishery Management Branch, Galveston Laboratory, National Marine Fisheries Service, Galveston, Tx.

estimates from a subsequent time period. Some red snapper assessment workshop participants, however, felt that these catch rates would be too low and recommended using the average CPUE from 1984-1989 multiplied by 8.5, which was consistent with the "high" recruitment scenario recommended by Reef fish stock assessment panels in prior years (REEFSAP, 1999):

$$(2) \qquad C_{manufactured,y} = 8.5 E_y \frac{\sum_{i=1984}^{1989} C_i}{\sum_{i=1984}^{1989} E_i} E_y, \qquad y < 1972$$

The results for the eastern and western regions, as well as Gulf-wide, are shown in Table 3 and Figure 5. Inasmuch as these catch values were not actually observed, but based on assumptions that are difficult to verify, it is desirable to provide variances that effectively down-weight their contribution to the objective function. An approximate CV was computed as follows:

$$CV_{manufactured} = \frac{\sqrt{V_{process} + V_{observation}}}{\overline{C}_{1984-89}}$$

(3)

$$V_{process} \approx s^2_{process} \sum_{y=1984}^{1989} E_y^2 / 6, \qquad V_{observation} \approx \left(\overline{CV}_{1984-89} \overline{C}_{1984-89}\right)^2$$

where $s^2_{process}$ is the sample variance of the *C/E* ratios in equation (2), $\overline{C}_{1984-89}$ is the average of the bycatch estimates for 1984 to 1989, and $\overline{CV}_{1984-89}$ is the corresponding average of the associated bycatch Cvs (the value of 8.5 cancels out of the CV formulation). This yielded values of 1.1, 1.0 and 0.94 for the east, west and Gulf-wide series, respectively (similar to the higher CV's associated with some of the bycatch estimates from the 1970's).

A second series was developed excluding age 0 fish, in which case

$$(4) \qquad C_{manufactured,1+,y} = C_{manufactured,y} * \overline{p}$$

where $\overline{p}$ is the average proportion of the bycatch older than age 0 during 1992 - 2003 (the only years when age-composition data were actually available, see Nichols 2004). These estimates are shown in Table 3. An approximate CV was computed as:

$$CV_{manufactured,1+} = \sqrt{\overline{p}^2 CV^2_{manufactured} + s^2_p}$$

where s_p^2 is the sample variance of the annual *p* values (the catch values cancel out). This yielded values of 1.2, 1.1 and 1.0 for the east, west and Gulf-wide series, respectively.

Acknowledgments

J. Nance provided the observed effort data and provided some helpful advice.

Literature cited

Captiva, F. J. 1967. Trends in shrimp trawler design and construction over the past five decades. Proc. Gulf Carib. Fish. Inst. 19:23-30.

Idyll, C. P. 1957. The commercial shrimp fishery of Florida. State of Fla. Bd. Cons. Educational Ser. 6: 28 p.

Iversen, E. S. and Idyll, C. P. 1959. The Tortugas shrimp fishery: The fishing fleet and its method of operation. State of Fla. Bd. Cons. Tech. Ser. 29: 37 p.

Joyce, E. and Eldred, B. 1966. The Florida Shrimping Industry. State of Fla. Bd. Cons. Tech. Ser. 15: 39 p.

Lyles, C. H. 1951. The development of the brown shrimp fishery in Texas. Proc. Gulf Carib. Fish. Inst. 3:50-51.

Nichols, S. 2004. Estimating Catch at Age for Red Snapper in the Shrimp Fleet Bycatch. SEDAR7-AW 20

REEFSAP. 1999. September 1999 Report of the Reef Fish Stock Assessment Panel. Final Draft - October 20, 1999. Gulf of Mexico Fishery Management Council. 3018 U.S. Highway 301 North, Suite 1000. Tampa, Florida 33619. gulfcouncil@gulfcouncil.org

Springer, S. 1951. Expansion of the Gulf of Mexico shrimp fishery, 1945-50. Commercial Fisheries Review. Vol. 13, No. 9. September 1951 (U.S. Dept. Interior Fish and Wildlife Service SEP. No. 289)

Table 1. Number of vessels recorded in the operating units file less the number recorded the year before the fishery started (as compared with days fished, 1960-1970).

	new vessels by state/region							days fished	
year	Tx	La	Ms	Al	Fl	West	East	West	East
1948	268					268	0		
1949	433					433	0		
1950	523			15	234	523	249		
1951	522	28*	28*	60	341	550	429		
1952	589	60	6	59	442	649	507		
1953	638	-5	35	65	460	633	560		
1954	773	62	-83	58	743	835	718		
1955	638	51	-52	73	827	689	848		
1956	744	155	156	91	827	899	1074		
1957	1057	70	141	109	926	1127	1176		
1958	1438	300	129	137	978	1738	1244		
1959	1370	487	147	165	1038	1857	1350		
1960	1327	534	103	165	828	1861	1096	70328	25420
1961	1347	261	115	130	834	1608	1079	63720	30402
1962	1081	204	119	111	782	1285	1012	65059	26947
1963	1162	561	100	190	806	1723	1096	76519	29524
1964	1193	642	73	173	860	1835	1106	85210	32275
1965	1177	598	77	238	804	1775	1119	84406	32754
1966	1215	641	78	309	845	1856	1232	95734	32025
1967	1481	720	19	340	850	2201	1209	102358	29358
1968	1621	746	154	410	947	2367	1511	94626	32761
1969	1612	801	132	449	891	2413	1472	117985	37565
1970	1529	992	120	391	772	2521	1283	119424	32770

*Springer (1951) reported a minimum of 28 shrimp trawlers operating near the Southwest Pass of the Mississippi River (La) in 1951. Inasmuch as the brown shrimp grounds extend to the SE as well, it is assumed that an equal number of vessels worked in that area as well (Ms). Negative numbers probably reflect a decline in the number of vessels fishing inshore for white shrimp that exceeded the increase in vessels fishing offshore for brown shrimp (some moving into more productive areas outside La and Ms, and others being retired). In any case, the offshore fisheries in La and Ms appear to be small compared to those off Tx and Fl, so misrepresenting the dynamics in these areas will have little impact on the regional summaries.

Table 2. 'Prehistoric' effort series, rescaled to days fished, suggested for use in the red snapper assessment (shaded region). The values for 1960-1971 are actual estimates provided by J. Nance (pers. Comm.).

Year	East	West
1947	0	0
1948	0	12191
1949	0	19697
1950	6393	23791
1951	11014	25019
1952	13017	29522
1953	14378	28794
1954	18434	37983
1955	21772	31342
1956	27574	40894
1957	30193	51266
1958	31939	79059
1959	34661	84472
1960	25420	70328
1961	30402	63720
1962	26947	65059
1963	29524	76519
1964	32275	85210
1965	32754	84406
1966	32025	95734
1967	29358	102358
1968	32761	94626
1969	37565	117985
1970	32770	119424
1971	29768	117151

Table 3. Time series of historical bycatch constructed using equations (2) and (4), essentially 8.5 times the average bycatch per unit effort during 1984-89 multiplied by the reconstructed effort series discussed above (see Table 2).

	age 0+			age 1+		
year	East	West	Gulf-wide	East	West	Gulf-wide
1948	0	7,079,343	6,274,751	0	2,499,044	2,215,019
1949	0	11,437,894	10,137,938	0	4,037,635	3,578,744
1950	854,181	13,815,286	15,535,623	301,530	4,876,866	5,484,154
1951	1,471,661	14,528,503	18,546,451	519,504	5,128,635	6,546,991
1952	1,739,236	17,143,634	21,895,119	613,959	6,051,790	7,729,089
1953	1,921,050	16,720,986	22,220,893	678,140	5,902,593	7,844,088
1954	2,463,060	22,056,909	29,038,313	869,473	7,786,201	10,250,672
1955	2,909,018	18,200,252	27,337,907	1,026,898	6,424,782	9,650,420
1956	3,684,299	23,747,499	35,241,241	1,300,576	8,382,988	12,440,337
1957	4,034,204	29,770,223	41,927,375	1,424,095	10,509,040	14,800,577
1958	4,267,475	45,910,070	57,131,480	1,506,440	16,206,488	20,167,703
1959	4,631,102	49,053,509	61,318,429	1,634,803	17,316,138	21,645,717
1960	3,396,441	40,839,877	49,282,119	1,198,961	14,416,684	17,396,839
1961	4,062,080	37,002,584	48,445,135	1,433,935	13,062,100	17,101,379
1962	3,600,516	37,780,092	47,356,231	1,271,000	13,336,565	16,716,990
1963	3,944,837	44,434,855	54,581,057	1,392,547	15,685,730	19,267,391
1964	4,312,287	49,482,073	60,470,141	1,522,259	17,467,423	21,346,267
1965	4,376,330	49,015,051	60,302,905	1,544,867	17,302,562	21,287,232
1966	4,278,983	55,593,359	65,758,562	1,510,503	19,624,738	23,213,107
1967	3,922,611	59,439,594	67,794,836	1,384,702	20,982,479	23,931,922
1968	4,377,347	54,949,537	65,566,834	1,545,226	19,397,466	23,145,426
1969	5,019,134	68,514,396	80,062,302	1,771,780	24,185,930	28,262,400
1970	4,378,443	69,350,219	78,335,050	1,545,613	24,480,980	27,652,671
1971	3,977,341	68,030,191	75,619,915	1,404,022	24,015,003	26,694,215

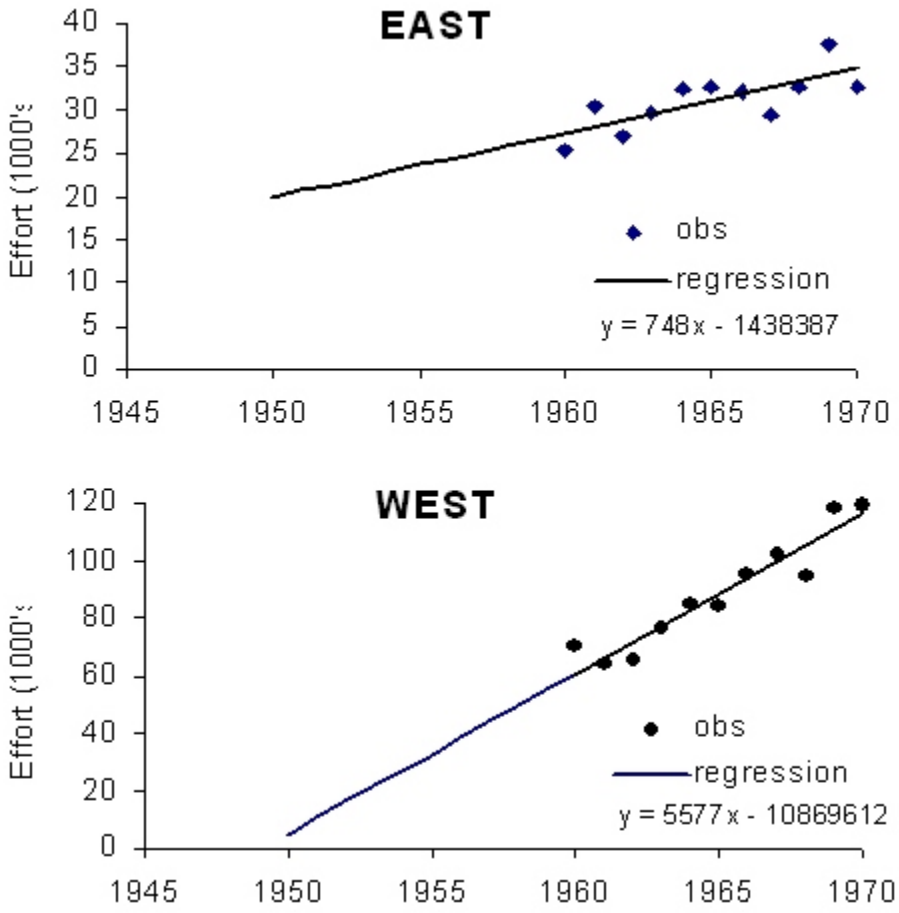

Figure 1. Linear regressions of effort against year for the period 1960-1970 with extrapolations to 1950.

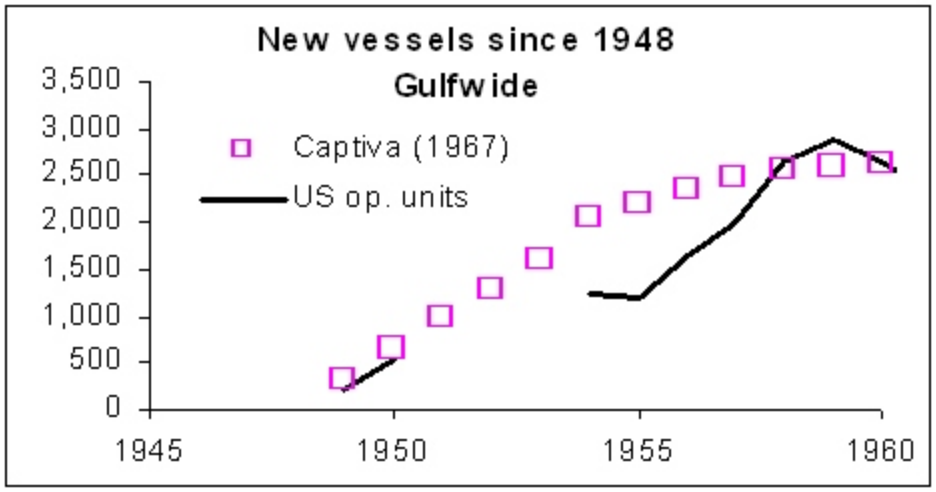

Figure 2. Comparison of the increase in shrimp trawling vessels recorded in the NMFS operating units file since 1948 with an independent estimates of the number of new trawlers produced in the U.S. (Captiva 1966).

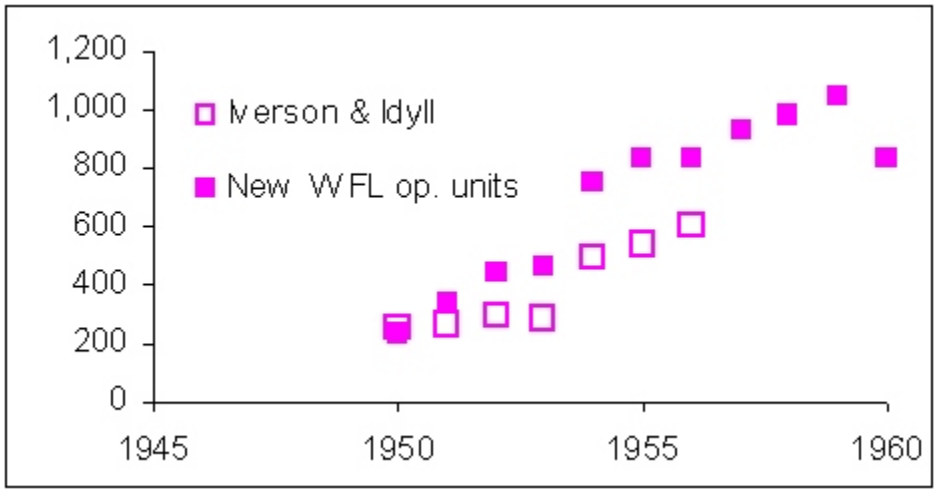

Figure 3. Comparison of the increase in shrimp trawling vessels recorded in the NMFS operating units file for West Florida since 1949 with an independent estimate of the number of trawlers operating on the Tortugas grounds (Iversen and Idyll 1959). The number for West Florida as a whole would be expected to be somewhat larger than for the Tortugas alone after 1950 owing to the discovery of important new grounds on the Campeche Banks and other minor grounds elsewhere in West Florida.

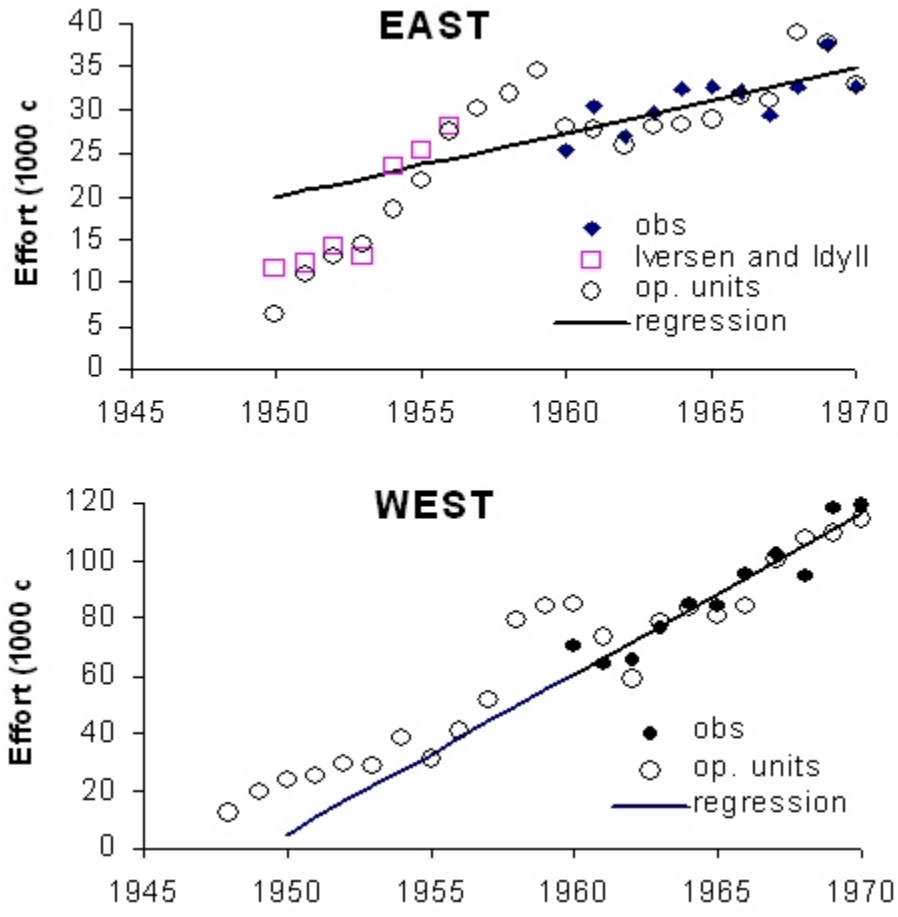

Figure 4. Time series of historical effort constructed from the operating unit files in comparison with the direct observations of Iversen and Idyll (1959) and the linear regression extrapolations.

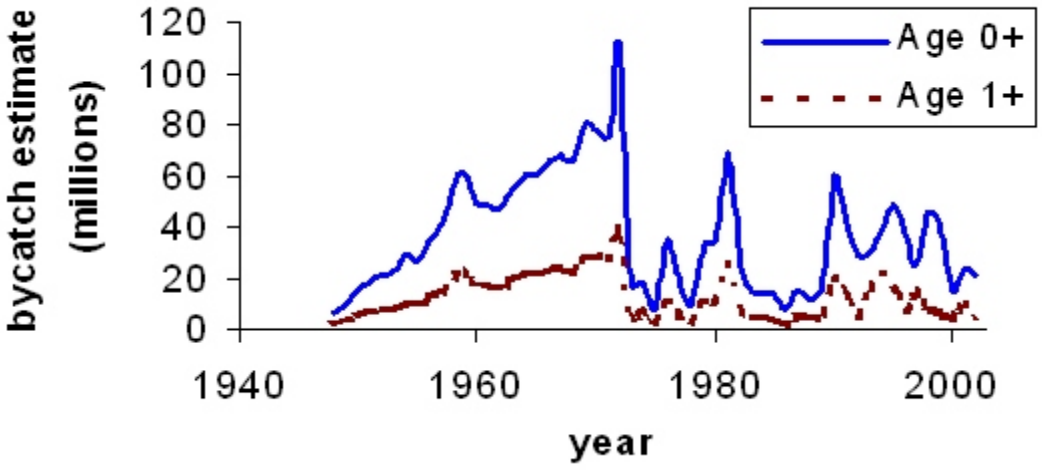

Figure 5. Gulfwide time series of historical bycatch constructed using equation (2), essentially 8.5 times the average bycatch per unit effort during 1984-89 multiplied by the reconstructed effort series discussed earlier.