The U.S. Gulf of Mexico Pink Shrimp, *Farfantepenaeus duorarum,* Fishery: 50 Years of Commercial Catch Statistics

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Introduction

The primary pink shrimp, *Farfantepenaeus duorarum*, fishing grounds consist of a small group of islands and reefs in the eastern Gulf of Mexico (GOM) where habitats are conducive to this species' survival and commercial fishing operations (Fig. 1) (statistical areas 1–3) (Iversen et al., 1960). Extensive study of this fishery after the discovery of commercially harvestable populations of *F. duorarum* in the late 1940's (Iversen et al., 1960) fueled concerns for the potential for overfishing expressed by Florida researchers and lawmakers during the 1950's (Iversen et al., 1960). Those concerns were mitigated in part by the establishment of sanctuaries which were closed to fishing for specified periods, thus allowing for the protection of *F. duorarum* stocks and increased fishery production upon resumption of fishing operations (Klima et al., 1986; Klima and Patella, 1985, and references contained therein for a synopsis of the fishery's management history).

Catch and effort statistics for the commercial *F. duorarum* fishery off of the west coast of Florida during 1960 through 2009 are documented herein. These catch statistics are used in National Marine Fisheries Service (NMFS) stock assessment models which estimate parent stock size and annual recruitment. These data are then used as indices to gauge the status of the population (Hart and Nance, 2010). These stock assessments are critical to future measurements of potential changes in fishing effort, total catch, spatial catch distribution, and catch rates (CPUE).

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ABSTRACT—U.S. Gulf of Mexico, pink shrimp, Farfantepenaeus duorarum, *catch statistics have been collected by NOAA's National Marine Fisheries Service, or its predecessor agency, for over 50 years. Recent events, including hurricanes and oil spills within the ecosystem of the fishery, have shown that documentation of these catch data is of primary importance. Fishing effort for this stock has fluctuated over the 50-year period analyzed, ranging from 3,376 to 31,900 days fished, with the most recent years on record, 2008 and 2009, exhibiting declines up to 90% relative to the high levels recorded in the mid 1990's. Our quantification of* F. duorarum *landings and catch rates (CPUE) indicates catch have been below the long-term average of about 12 million lb for all of the last 10 years on record. In contrast to catch and effort, catch rates have increased in recent years, with record CPUE levels measured in 2008 and 2009, of 1,340 and 1,144 lb per day fished, respectively. Our regression results revealed catch was dependent upon fishing effort ($F=98.48_{df=1,\ 48,}$ $p<0.001$, $r^2=0.67$), (Catch=1,623,378 + (520) × (effort)). High CPUE's measured indicate stocks were not in decline prior to 2009, despite the decline in catch. The decrease in catch is attributed in large part to low effort levels caused by economical and not biological or habitat related conditions. Future stock assessments using these baseline data will provide further insights and management advice concerning the Gulf of Mexico* F. duorarum *stocks.*

Methods

Commercial harvest records for *F. duorarum* collected since the 1950's (Iversen et al., 1960) include monthly statistics such as catch, value, size distributions, fishing effort, and catch per unit of effort (CPUE) from the GOM, using standard methods. NMFS port agents and state trip tickets record the daily operations and shrimp production of the commercial fisheries fleet operating within the boundaries of the eastern GOM. Scientists have subdivided the U.S. Gulf of Mexico into 21 statistical subareas (Patella, 1975) used by port agents and the state trip ticket system to assign the location of catches and fishing effort expended by the shrimp fleet on a trip by trip basis.

The *F. duorarum* fishing grounds are located primarily within subareas 1–11 (Fig. 1). Port agents randomly visit fishing ports throughout the GOM to interview fishing captains and/or crews and record data pertaining to trawling activity (effort). These data include; 1) the location and depth fished by statistical subarea; 2) the species-specific pounds and sizes of shrimp landed; and 3) commercial value of the catch for each individual trip that a vessel has completed (Nance et al., 1989).

To calculate effort (i.e., the amount of time in hours the trawls are actually in the water fishing), catch, and CPUE statistics were calculated according to the methods outlined in Nance et al. (2008). An electronic logbook program (ELB) was initiated in 1999 to augment shrimp fishing effort measurements. Gallaway et al. (2003a, b) provides a description of the ELB program and data

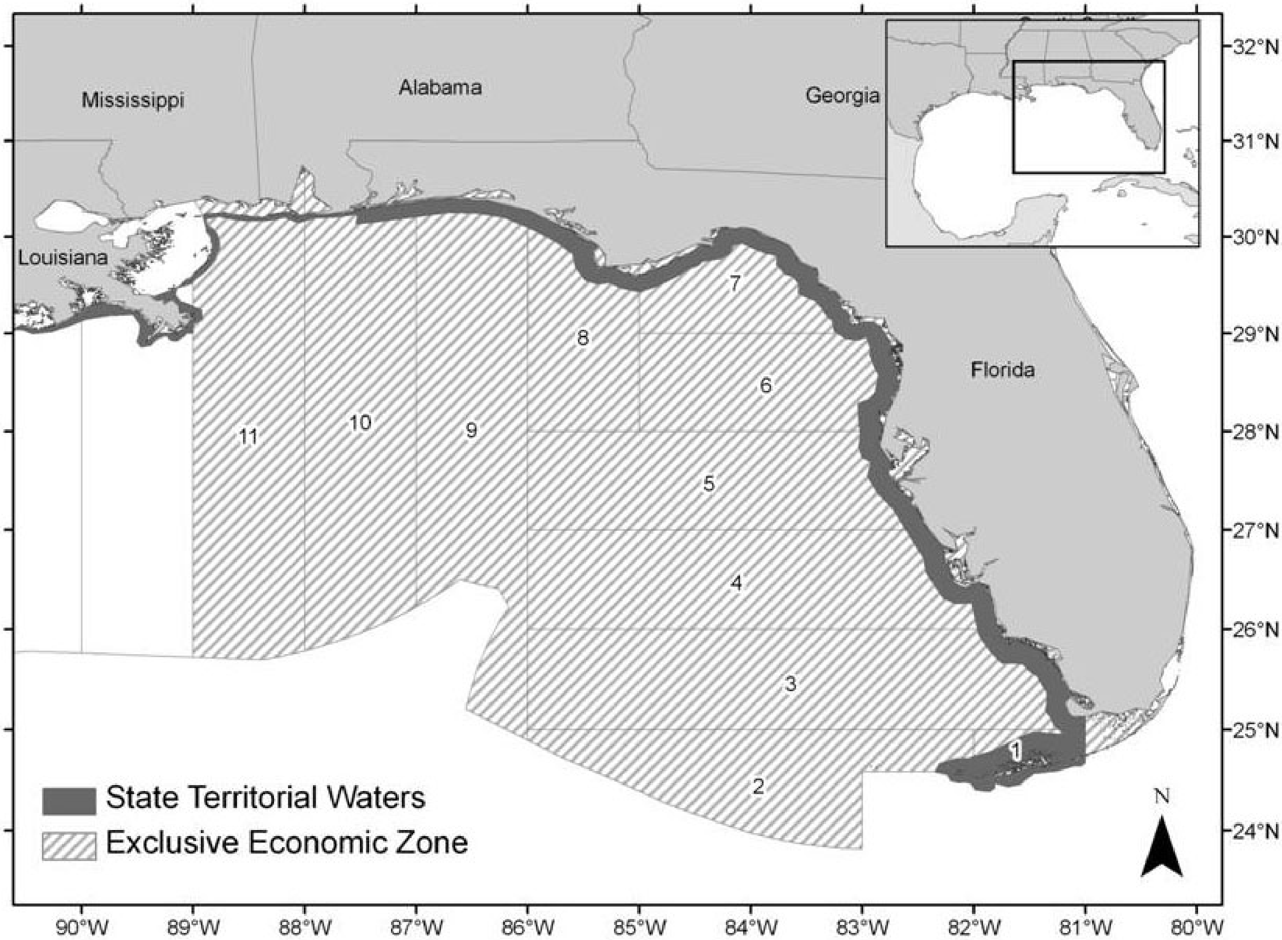

Figure 1.—U.S. Gulf of Mexico *Farfantepenaeus duorarum* fishing grounds, statistical zones 1–11.

collection procedures. The ELB data are used to supplement effort and location data collected by NMFS port agents and state trip tickets.

The commercial shrimp statistics are entered into an Oracle[1] relational database maintained and managed by fisheries staff under the direction of the NMFS Southeast Fisheries Science Center, Miami, Fla. We have summarized those 1960–2009 catch statistics prerequisite to generating baseline information used in the NMFS *F. duorarum* stock assessments (Hart[2]). We also examine relationships between effort, catch, and catch rates using simple correlation and regression methodologies (Zar, 1984).

[1]Mention of trade names of commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

[2]Hart, R. A. 2010. Gulf of Mexico 2009 Pink shrimp stock assessment. A report to the Gulf of Mexico Fisheries Management Council, 6 p.

Results

Fishing Effort

Fishing effort, measured in 24 h days fished (i.e., trawls in water) fluctuated over the 50-year period presented in this analysis, ranging from 3,376 to 33,900 days fished (Fig. 2). While effort values were relatively stable (approximately 18,000–25,000 days fished, with some annual variability from 1960 to 1987), during the late 1980's and early 1990's effort declined to about 17,000 days fished. Effort levels began to increase after 1994, eventually peaking to over 30,000 days fished during 1996–97. Following the period ending in 2005, effort dropped to the lowest levels on record, with fishermen only expending about 3,400 days fished in 2009.

Annual Shrimp Catch

F. duorarum catches from 1960 through 2009 averaged 11.9 ± 4.1 million lb (SD) (Fig. 2) (Table 1). The highest catch on record was in 1964 (21.3 million lb). Catch subsequently declined, but then peaked again in 1981. Catch declined sharply after the 1981 season, falling to 5.9 million lb in 1992. Following the 1992 low, catch increased to 19 million lb in 1996 (Fig. 2). From the late 1990's through the mid 2000's catch was about 7–10 million lb/yr. However, beginning in 2006 yield began to decline with the lowest catch

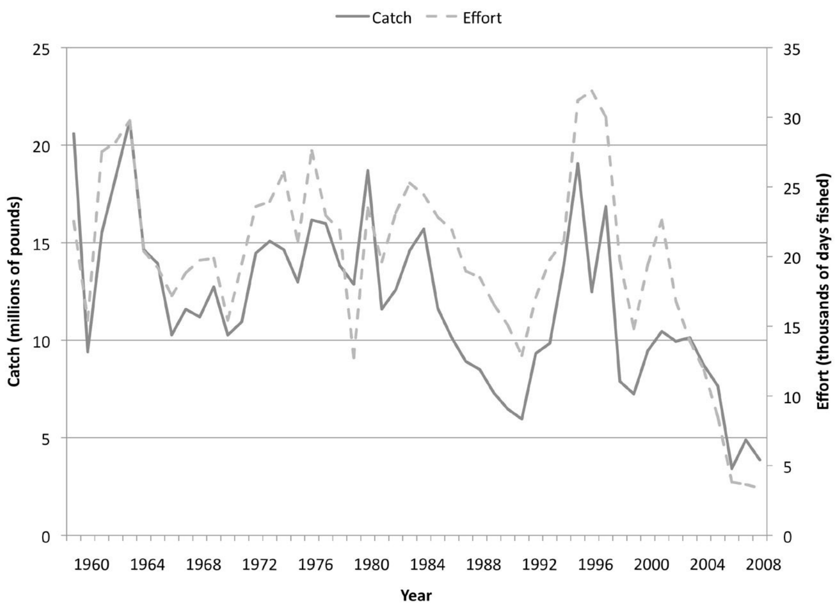

Figure 2.—*Farfantepenaeus duorarum* catch and effort vs. year, 1960–2009.

Table 1.—U.S. Gulf of Mexico *Farfantepenaeus duorarum* commercial catch statistics, 1960–2009.

Year	Catch (lb of tails)	CPUE (lb/day fished)	Effort (days fished)
1960	20,593,069	914	22,543
1961	9,406,690	610	15,425
1962	15,497,237	563	27,519
1963	18,370,468	651	28,238
1964	21,252,688	714	29,779
1965	14,642,255	718	20,389
1966	13,926,713	725	19,202
1967	10,273,175	598	17,189
1968	11,589,136	615	18,840
1969	11,191,377	567	19,739
1970	12,732,458	640	19,883
1971	10,262,473	666	15,418
1972	10,942,805	562	19,477
1973	14,463,616	613	23,594
1974	15,078,522	630	23,952
1975	14,643,411	562	26,056
1976	12,978,663	617	21,040
1977	16,165,122	585	27,618
1978	15,977,848	696	22,949
1979	13,830,369	632	21,890
1980	12,865,040	1,010	12,738
1981	18,703,132	796	23,504
1982	11,594,374	591	19,622
1983	12,589,459	544	23,158
1984	14,604,879	578	25,277
1985	15,699,557	642	24,440
1986	11,632,220	509	22,835
1987	10,123,201	462	21,928
1988	8,910,101	470	18,960
1989	8,497,586	459	18,507
1990	7,300,883	441	16,569
1991	6,469,751	429	15,083
1992	5,958,821	462	12,896
1993	9,327,618	546	17,081
1994	9,839,113	497	19,785
1995	13,861,084	656	21,133
1996	19,053,469	611	31,209
1997	12,476,766	391	31,900
1998	16,856,192	561	30,021
1999	7,895,197	400	19,739
2000	7,243,949	489	14,823
2001	9,459,139	487	19,429
2002	10,455,653	462	22,629
2003	9,943,416	591	16,828
2004	10,133,824	727	13,938
2005	8,722,912	735	11,874
2006	7,653,941	901	8,496
2007	3,414,746	894	3,818
2008	4,888,385	1,340	3,648
2009	3,861,071	1,144	3,376

on record for this time series occurring in 2007, with only 3.4 million lb of *F. duorarum*. Catch rebounded to 4.9 million lb in 2008, decreasing to a low of 3.9 million lb a year later.

Catch Per Unit of Effort (CPUE)

Catch per unit of effort (CPUE), reported as pounds of shrimp caught during a 24-h fishing day (pounds per nominal day fished), averaged 634 lb/day fished in statistical areas 1–11 (Table 1) during 1960–2009. The CPUE of 391 lb/day fished during 1997 was the lowest harvesting rate for this 50 yr time series. CPUE began to increase from the 1997 low in 2003. This increase continued through 2009, relative to the low CPUE's of the late 1990's, and despite a trend of decreasing catch. Record high catch rates were recorded in 2008 and 2009 with 1,340 and 1,144 lb/day fished, respectively (Table 1).

Discussion

Collection of commercial fishing statistics for *F. duorarum* was initiated in the 1950's during this fishery's early development (Iversen et al., 1960). These statistics have been used to elucidate trends and changes in the fishery and, while they are fishery dependent, they do illustrate the population's behavior when data sets are viewed in conjunction with one another. For example, CPUE trends developed from catch and effort data not only illustrate the fishing efficiency of the fleet and availability of the shrimp to harvest, and in so doing, may be used as an index of the population's abundance (Quinn and Deriso, 1999).

The effort decrease we measured in 2008 represents an approximate 90% reduction in fishing effort when compared to the high levels recorded in 1997. These declining effort levels are likely due to the adverse economic conditions the fishing community experienced during this time period (Travis and Griffin[3]). Factors contributing to this decline include: the devastation caused by hurricanes Katrina and Rita (2005) and Gustav and Ike (2008); an increase in low-cost shrimp imports onto the American market (Keithly and Roberts, 2000; Haby et al., 2003); and an increase in marine fuel prices (Haby et al., 2003).

Related to these low effort levels, catches have been below the long-term average for all of the last 10 yr of recorded landings. Previously, decreasing catch was thought to have been due to habitat degradation (O'Conner and Matlock, 2005), primarily in Florida Bay (Robblee et al., 1991), and decreased freshwater inflows (Sheridan, 1996). However, in recent years the primary reason for reduced harvests appears to be attributable to the record low effort levels in this fishery.

O'Conner and Matlock (2005) proposed that landings from this fishery were independent of fishing effort. Conversely, we believe catch declined in response to reduced fishing effort and

[3]Travis, M. D., and W. L. Griffin. 2004. Update on the economic status of the Gulf of Mexico commercial shrimp fishery. U.S. Dep. Commer., NOAA, NMFS SERO-ECON-04-01, 10 p.

the data reflect a positive relationship between catch and effort ($F=98.48_{df=1,48}$, $p<0.001$, $r^2=0.67$) (Fig. 3). If the decrease in catch was due to low effort levels, as we propose, this would indicate that catches declined in recent years because of economic conditions and not because of reduced habitat and hence shrimp stocks. We believe that catch is driven by effort, vs. effort being driven by catch, and this is supported by the trend of increasing catch rates during those periods of low-effort expenditures.

Catch rates in the last 2 yr of our dataset are about two times greater than the long-term average. While decreases in both catch and effort during the later years are evident, disproportional changes in these parameters have resulted in an increase in CPUE for fishermen able to harvest *F. duorarum*. There was no positive correlation between catch and CPUE throughout this time series. Instead, CPUE increased as catch and effort declined to historically low levels (Fig. 4, 5), due to effort declining at a disproportionally higher rate than did catch. This suggests that catch is not necessarily a good measure of *F. duorarum* stock size in the GOM. Like that for other species, CPUE is a more accurate descriptor or proxy for stock size than catch alone (Quinn and Deriso, 1999).

As long as CPUE is shown to be a good measure of relative abundance (Quinn and Deriso, 1999, and references therein), the high catch rates we have recently measured are an indication that the *F. duorarum* population has remained large enough to not be negatively affected by current catch levels. This finding also is evident in the most recent GOM *F. duorarum* stock assessment modeling results (Hart and Nance, 2010; Hart[2]). The assessment model results provide another indication that the fishery during this time period is not in decline. The recent low harvest levels are likely due to economic conditions, manifested by low effort levels, not to unsuitable habitat or poor biological conditions.

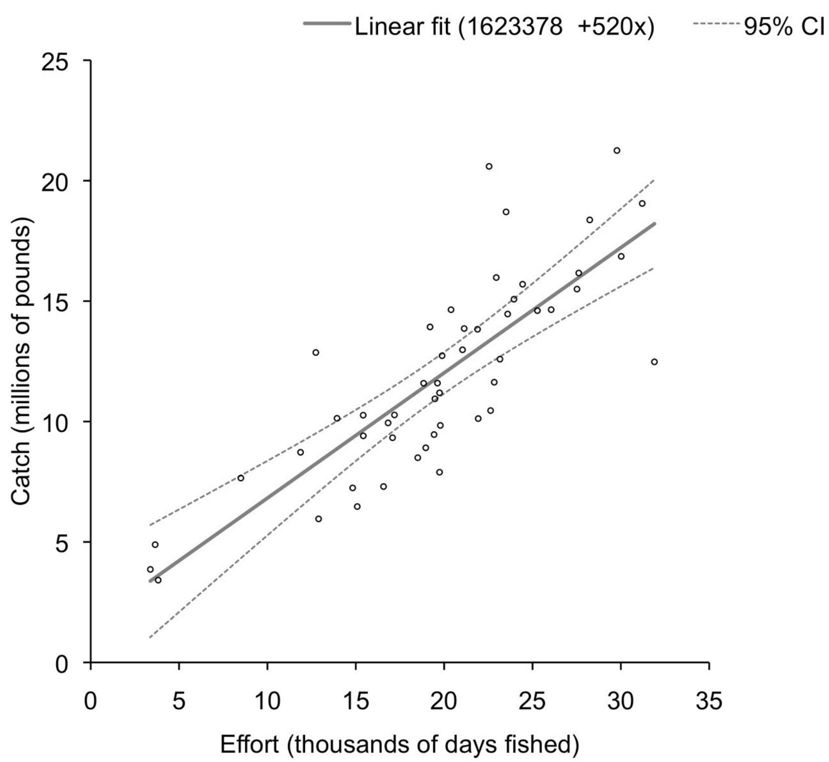

Figure 3.—*Farfantepenaeus duorarum* catch vs. effort linear regression, 1960–2009.

Changes in juvenile habitat, e.g., freshwater flow pattern alteration (Sheridan, 1996), sea grass die-off (Robblee et al., 1991), high water temperatures and/or salinity in Florida Bay, etc., have been suspected to be the cause for declines in shrimp populations (Sheridan, 1996). Declines in Florida Bay habitats, an area necessary for *F. duorarum* survival and growth, are well documented to have negative consequences for GOM populations (Browder et al., 1999; Browder and Robblee, 2009). These habitats serve as the primary nursery area for this Gulf shrimp species (Sheridan, 1996).

However, no recent biological causes for the current declines in *F. duorarum* catches along the Florida coast have been documented. While we did not attempt to measure habitat changes, we believe if biological parameters, e.g., poor recruitment due to habitat loss caused by the aforementioned possibilities, were a large factor in recent downturns in shrimp catch, we would be observing a decline in catch with stable or even increasing fishing effort. In contrast, some of the highest CPUE levels recorded in recent years indicate shrimp are available for harvest by fishermen financially able to target them. Currently, low yields and effort levels in the *F. duorarum* fishery seem better explained by economic rather than biological conditions.

Decades of catch and effort data have enabled the development of robust stock assessment models that successfully measured the performance and "health" of the fishery in the past (Iversen et al., 1960; Klima et al., 1986; Nance and Patella, 1989; Nance et al., 2008; Nichols[4]; and more recently by Hart[2], who is developing an integrated *F. duorarum* Stock Synthesis model [Methot, 2009; Hart and Nance, 2010]). The primary model historically deployed in the NMFS *F. duorarum* assessments was a virtual population analysis (VPA)

[4]Nichols, S. 1984. Updated assessments of brown, white, and pink shrimp in the U.S. Gulf of Mexico. Paper presented at the SEFC Stock Assessment Workshop. Miami, Florida, May 1984, 53 p.

(Ricker, 1975) that estimated the number of parents (i.e., parent stock) used as an index of health of the population. Inability of the 2008 VPA to track the decline in fishing effort (see Appendix 1 in Hart and Nance, 2010) resulted in it being replaced with the aforementioned Stock Synthesis model (Hart and Nance, 2010). This new model has successfully tracked the observed extreme changes in catch, effort, and catch rates. Having these long-term baseline catch data puts the NMFS in a unique position to better measure future biological and economical impacts on this fishery.

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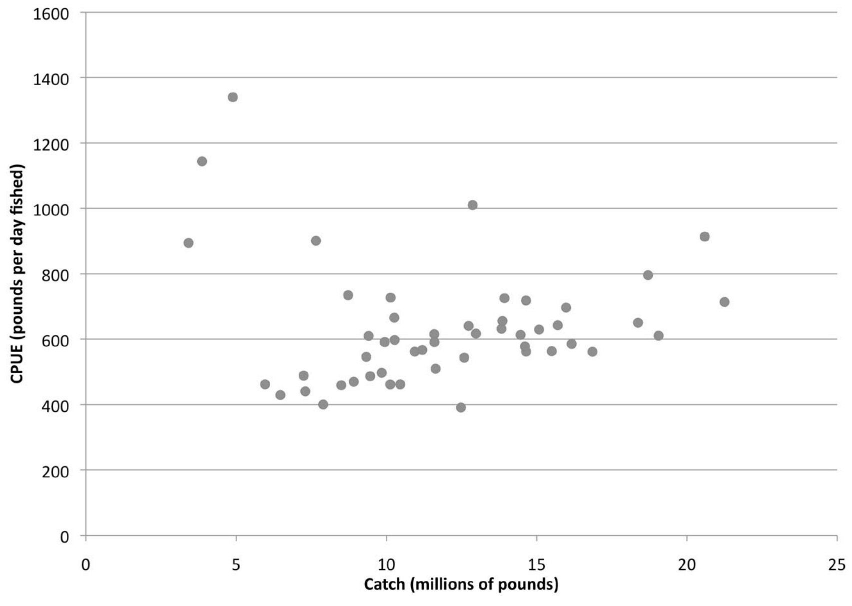

Figure 4.—*Farfantepenaeus duorarum* catch rate (CPUE) vs. catch, 1960–2009.

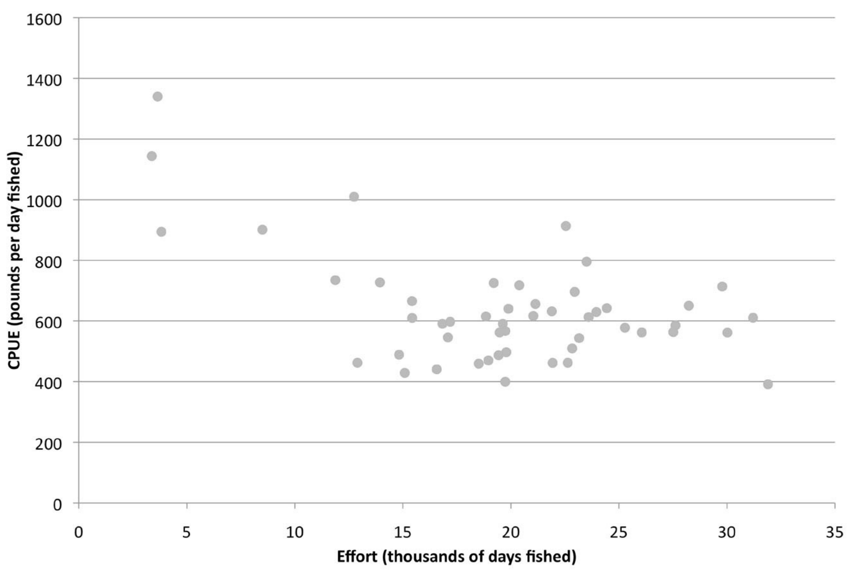

Figure 5.—*Farfantepenaeus duorarum* catch rate (CPUE) vs. effort, 1960–2009.

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