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 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).

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.
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 \textit{F. duorarum} stock assessments (Hart\(^2\)). We also examine relationships between effort, catch, and catch rates using simple correlation and regression methodologies (Zar, 1984).

\section*{Results}

\subsection*{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.

\subsection*{Annual Shrimp Catch}

\textit{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...
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). 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
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; Hart4). The assessment modeling 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 unsustainable habitat or poor biological conditions.

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; Nichols4; and more recently by Hart2, 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)

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*Figure 3.—* *Farfantepenaeus duorarum* catch vs. effort linear regression, 1960–2009.
(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 economic impacts on this fishery.

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Literature Cited


