Investigations and Demonstrations Leading to Enhanced Fuel Efficiency in the Southeast Shrimp Fishery: A Final Report Outlining Work Undertaken and Achievements To Date

(Contract: CM725 / TAMU Sponsored Project: 0000421118)

May 1, 2007 – February 28, 2010

Prepared for

The State Energy Conservation Office
Austin, Tx

Marvin Barr – Program Manager

Prepared by Extension Specialists in the Departments of Agricultural Economics and Wildlife & Fisheries Sciences

Texas AgriLife Extension Service
Sea Grant College Program
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Table of Contents

Executive Summary

Introductory Remarks

Meaningful assistance for the beleaguered, domestic shrimp industry cannot occur fast enough! As the proposal to conduct this work for the Texas shrimp industry was being completed, nominal dockside prices had declined by 58% from 2000, fuel prices were sharply escalating, and at the median, a gallon of diesel was required to land about 14 oz. of shrimp. Though the shrimp industry won all six antidumping cases in 2005, imports continued relatively unabated. In particular, annual shrimp imports grew by an average of 34 million lb. each year between 1990 and 2000. However, between 2001 and 2008, the average, annual growth in import volumes more than doubled to 73 million lb. per year.

Improving Economic Performance with Funding from the State Energy Conservation Office (SECO)

SECO efforts sought to improve the economic performance of offshore shrimp fishing by driving avoidable costs out of the enterprise. Project directors designed and implemented a research effort with elite producers to examine ways of reducing fuel use.

Two tracks were considered. The first was adaptation and evaluation of a new type of trawl door that uses airfoil technology, as opposed to resistence, to spread the nets. In addition, small-diameter, high-tensile-strength, braided, Sapphire® webbing was used for the nets. This high-density polyethylene material is a stronger, smaller, less resistive choice than nylon. Less resistance generated by the trawl means fewer RPM necessary to maintain towing speed. This directly translates into reduced fuel use. In the second track, funds were used to evaluate the additional contribution a relatively new type of propeller makes to fuel savings. According to FAO, *"the propeller is the most significant technical item on a fishing vessel, with design and specification having a direct impact on fuel efficiency.*" Comparing fuel consumption realized with two different propeller designs (i.e., the Kaplan-style traditionally used in the shrimp fishery and the newer, skewed style) established the additional contribution a skewed propeller can make to total fuel efficiency for the trawling enterprise.

In the short run, reducing fuel consumption while maintaining current catch rates would help remaining producers better absorb other economic shocks to the production enterprise. Unfortunately, historically-low dockside prices – not seen since the seventies – are the latest economic shock, and have resulted from the mortgage/banking debacle surfacing in late 2008 and the ensuing recession with record unemployment levels.

Results and Impacts Generated with SECO Funding

Reducing fuel consumption and expense. Cooperative research with elite producers documented fuel savings that ranged from 10% to 39% with savings at the 25th percentile amounting to 20%, while fuel savings at the median and 75th percentile respectively were 24% and 29%. Roughly 80% of the Cameron County fleet (132 vessels) switched to the new fuel-efficient gear in early 2008. In just two years, county-wide fuel savings were estimated to be 4.88 million gallons valued at $12.1 million. In addition to immediate reductions in fuel expense, the fuel-saving trawl gear also reduces the frequency of oil and filter changes. Furthermore, reduced fuel use extends the interval for top-end and major overhauls which halves the expense of this maintenance over the estimated 16-year engine life.

Owing to the purchase and installation cost of a new propeller, only one vessel was used in this trial. Engine performance, ground speed and fuel consumption were recorded during fishing operations using both the traditional and new propellers. Over some 545 total observations, the skewed propeller resulted in a 0.9 gal./hr. savings (6.1%). This computed, per-hour fuel savings value is very conservative! Specifically, performance data logged when the Kaplan-style propeller was in use occurred during late summer/early fall, but performance data generated with the new, skewed wheel were collected in the heart of the winter fishing season which is characterized by stronger, heavier seas and faster currents.

Third-party initiatives. Outreach efforts addressing the fuel-saving gear have spawned important pilot programs by third parties. For example, state laws in Louisiana and Mississippi were changed to permit use of the fuel-saving trawl gear. One NGO now offers a pilot program to cover half the cost of converting to the new trawl gear; an $8,850 saving per vessel. This is a godsend since most financing historically available to the shrimp industry vanished with the advent of the revenue crisis in 2001. An eco-marketing organization that supplies sustainably produced, *"environmentally-friendly"* seafoods to retail establishments has started a pilot effort with selected, local producers to market wild shrimp harvested with the fuel-saving trawl gear and required environmental gear such as turtle excluder devices (TEDs) and by-catch reduction devices (BRDs). Quoted prices by this niche distributor have been much higher than those offered by the larger market. This suggests that participating operators may finally begin to grow their profit margins with the combination of (a) historically-high catch rates coupled with (b) higher dockside prices for shrimp and (c) less expenditures for fuel.

Investigations and Demonstrations Leading to Enhanced Fuel Efficiency in the Southeast Shrimp Fishery: A Final Report Outlining Work Undertaken and Achievements To Date

Introduction, Organization of the Report & Current Operating Conditions in the Shrimp Industry

Introduction

As the proposal to conduct this work for the shrimp industries along the Texas coast and the other Southeastern states was being prepared, the dockside prices received for shrimp continued to fall[1], the prices paid for fuel were escalating,[2] and, at the median, a gallon of fuel was required to land just over 14 oz. (¾ lb.) of shrimp.[3] Thus, driving avoidable costs out of the shrimp-trawling enterprise while still catching the same quantity of shrimp was deemed a critical contributor to economic viability for those remaining in the fishery. Trawl fisheries use large quantities of fuel to hunt and harvest targeted species, and the shrimp industry is no exception. Since 2001, fuel has been a rapidly-growing input expense for the offshore shrimp producer. In 1997 the cost for 66,101 gallons – the median quantity of fuel used between 1986 and 1997 – was $49,576. By 2006, the cost for those 66,101 gallons had risen to $144,596, and in 2008 the median quantity of fuel used would have cost almost $210,000.

Unlike industry-wide product marketing and quality certification efforts which offer the greatest potential over the long run and require group consensus, reducing production costs are individual decisions that require an understanding of the impact(s) new technology can make upon the trawling enterprise. The goal of this project was to explore the contributions new harvest and propulsion technology could make toward reducing (a) avoidable input costs – notably fuel, and (b) those preventive maintenance expenses that are a function of engine service hours or throughput of fuel. Project directors felt this approach was the fastest, best way to improve future, economic performance of offshore shrimp fishing across the Gulf and South Atlantic states.

One way to reduce fuel consumption during shrimp-trawling operations is to design (or adapt) trawl gear which creates less resistance once deployed. A single trawl is comprised of two main components: (a) the net system and (b) the otter boards (or trawl doors) that are attached between the net(s) and the main towing cables. Trawl doors spread the net(s) as the vessel moves forward. Fuel consumption increases when trawls are deployed because the additional resistance from the array of towed fishing gear requires more RPM to

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1. A review of average, annual, prices received by Texas shrimp producers in 2000, 2003, and 2006 vividly illustrates the drop in ex-vessel prices. In 2000, fishermen received $9.18/lb. for under-15 count shrimp. By 2003 these shrimp were worth $5.68/lb.; a drop of $3.50 (38%) while 2006 reflected a price of $5.09/lb., a 45% decline from 2000. Ex-vessel prices for 21-25 count tails averaged $5.67/lb. in 2000, $3.85/lb. in 2003, and $2.80/lb. in 2006. Expressed in percentage terms, 21-25 count tails declined by 32% between 2000 and 2003 while the 2006 price was just over half of the annual 2000 ex-vessel price. First-of-the season 41-50 count tails fell from $3.94/lb. in 2000, to $2.14/lb. in 2003, to $1.66/lb. in 2006. On a percentage basis, 2003 reflected a 46% drop from 2000 while 2006 prices declined by 58% from those paid in 2000 [1].

2. Between 2001 and 2005, diesel prices have effectively tripled from $0.70 to $2.00/gal. Over the three years following 2005, diesel prices doubled to more than $4.00/gal. but declined through the end of 2008 until April 2009 [2].

3. Based on information collected under a Standardized Performance Analysis (SPA) of Texas offshore shrimp producers between 1986 and 1997, offshore operators historically used between 58,775 and 73,485 gallons of diesel each year. These two values represent the 25th and 75th percentiles. Median, annual fuel use was 66,101 gallons. The SPA of shrimp producers provided a fertile data source that enabled us to compute various performance ratios that summarized financial position, financial performance, and operational efficiency. One example of operational efficiency was the ratio "pounds of shrimp sold per gallon of fuel used." Over the 12-year time frame, the computed, median value was 0.889 lb./gal. (or 14.2 oz. /gal.). This midpoint was bracketed at the 25th percentile value by 0.777 lb./gal. (or 12.4 oz./gal.) and at the 75th percentile value by 1.033 lb./gal. (or 16.5 oz./gal.) [3].

maintain enough vessel speed to keep the nets spread.[4] Both components of trawl systems – webbing and trawl doors – were considered as candidates for more fuel-efficient, shrimp-fishing operations. To reduce fuel consumption during shrimp-trawling operations, less resistive trawl gear never before used in the Gulf and South Atlantic shrimp fishery was located, tested, modified, and ultimately subjected to broad-scale testing by cooperating, elite producers. Companion funds from USDA allowed project directors to conduct identical trials across other Gulf and South Atlantic states too.

Exploring how best to achieve additional fuel savings (i.e., beyond what the new trawl gear could offer) during both towing and free running focused on replacing the standard type of propeller used on offshore shrimp trawlers (i.e., the Kaplan style) with one of several newer configurations (i.e., the skewed style) that has not been subjected to *"before and after"* testing in the offshore shrimp fishery. Given our anticipated budget constraint, one cooperator already using the new trawl gear would explore the additional fuel-saving capabilities of a new, skewed propeller. SECO funds were the sole source for evaluating the fuel-conservation impacts made with the new propeller. The Captain of the F/V Beth Lomonte – the vessel chosen to conduct this before and after comparison – began recording ground speed, engine RPM, and fuel consumption generated with the Kaplan-style propeller in September 2007, and completed data collection with the Kaplan-style propeller in early November 2007. Over this two-month period, the Captain generated 250 observations that comprised the baseline data set. The new, skewed propeller was installed on January 22, 2010. The vessel left for the fishing grounds on January 26th and returned to port with performance data generated by the skewed-propeller in mid-March. Project directors received engine performance data generated with the skewed propeller on March 29, 2010. On March 30, 2010 some 295 records were key-entered into a machine-readable data set and project directors began verifying, validating, analyzing, and summarizing the "before and after" information on April 5, 2010.

Organization of the Report

This report reviews the activities undertaken to support the overall project goal of reducing fuel use aboard the offshore shrimp trawler. We divide the remainder of this report along the two tracks detailed above: exploring the fuel-conservation effects of less-resistive trawl gear and examining fuel-conservation effects from retrofitting a shrimp trawler with a new type of propeller.

The Trawl Gear Track

Work done with the experimental trawl gear began far ahead of retrofitting a vessel with a new propeller, and required the *"lion's share"* of time. As noted in the opening sentence of this report, remaining operators face dire economic operating conditions, and are simply trying to survive to fish another day. Thus, the suggestion of more fuel-efficient trawl doors – that spread the nets through airfoil principles but required a different type of connection to towing bridles – was dismissed by many fishermen. Even some of the more progressive operators balked at the new gear because they felt the learning curve necessary to capitalize on the benefits was very steep. Nevertheless, exploring the fuel-efficiency of less-resistive trawl gear is essential in times like these because potentially large reductions in fuel consumption and expense are at stake.

4. The targeted species determines the type and size of trawl systems. In the New England groundfish industry, vessels typically use one trawl that fishes along the sea floor. Conversely, gulf shrimp fishermen who target brown shrimp typically tow four nets with the main towing cable coming off each outrigger. Towing cables in the offshore shrimp fishery are outfitted with three leads spliced into the main towing cable called bridles. To pull a twin-trawl system on each side of the vessel , two of the three leads per side connect to the trawl doors (one on the outside trawl door and the other on the inside trawl door with the middle lead connecting to a sled or "dummy door" that is connected to the head rope and foot rope of the inside and outside nets on each side of the vessel. (Figure 5 on page 10 shows a sled attached to head and foot ropes of the inside and outside nets during trawling operations.) Gulf shrimp fishermen who target white shrimp typically fish with two large-volume nets, and the middle connecting lead in this instance attaches directly to the bib or top of the net. Shrimp fishing requires large amounts of webbing in the water, and four trawl doors. To spread this net array requires significant power from the main engine because of the resistance created by the doors and nets.

Furthermore, trawling occupies a large fraction of the annual time an offshore vessel operates. In the Texas brown shrimp fishery, offshore vessels generally spend four hours trawling for every hour spent running.[5] The first step in this track was to test and adapt *"off the shelf"* experimental trawl doors to the rigors of offshore shrimp fishing with four nets. The second step was to conceive, design, and implement a cooperative research process that allowed elite producers to compare their current trawl system with the experimental gear across the performance parameters of engine performance, fuel use, and shrimp production.

In addition to outlining the approach we used to create new performance information generated by the experimental trawl gear and share it with a variety of stakeholders, this track of the report also highlights the results, accomplishments, and impacts generated by this work. We are extremely gratified with several notable achievements attributable to SECO-funded efforts. In addition, our fuel-conservation efforts have spawned some impressive outcomes and impacts for the domestic shrimp industry by others not associated with either the State Energy Conservation Office or the Texas A&M University System. We call these "third-party initiatives" which are best described as next steps in the continuum of work necessary to improve the future economic performance of what, historically, was America's most valuable commercial fishery. A detailed review of these achievements, outcomes, impacts, and third-party initiatives complete this track of our work to reduce production expenses among the offshore shrimp fleet.

The Skewed Propeller Track

Work to evaluate the contribution a new propeller makes to fuel savings <u>above</u> what the new trawl gear provides was completed later in this project. The vessel targeted for this retrofit spent some fifteen months off Florida's gulf coast taking advantage of higher dockside prices for unusually-abundant pink shrimp while collecting baseline information (Fall 2007). However, the retrofitting process was not completed until late January 2010. With the new, skewed propeller installed, the vessel spent some six weeks offshore fishing and logging performance data generated with the new propeller. Therefore, even with a complete set of *"before and after"* data, we can only report the results generated by this work. Accomplishments, impacts, and "third-party initiatives" generated from this track will require additional time to bear the fruit of results.

Unintended Consequences

Not all of our work was as successful as we hoped. We take responsibility for those unsuccessful elements, but one distraction for our target audience has been the crushing operating conditions offshore operators have faced since late 2001. These conditions and the adaptations surviving operators have made out of necessity contributed to some expectations not being met prior to the ending date of this effort. A summary of these operating conditions concludes this section.

Industry Operating Conditions from 2002 to the Present

Record prices – on the low end for shrimp and on the high end for fuel – have pushed many operators out of the Gulf and South Atlantic shrimp fishery. This section highlights the prime contributors to a punishing, multi-year assault on the domestic shrimp industry, and suggests that in the short run reducing avoidable costs will make the difference between continued operations and having to abandon both a livelihood and a way of life.

5. In the Texas offshore brown shrimp fishery, fleet-wide fishing effort has been measured by an electronic device known colloquially as an *"electronic log book or ELB."* The ELB records and stores compass heading and ground speed over elapsed time for subsequent retrieval at the dock. Collectively , these data provide a "time budget" for the activities of cooperating vessels. At the median, an offshore trawler seeking brown shrimp annually spends 37.2 percent of the time trawling (1,176 hrs.), 9.6 percent of the time running (303 hrs.), and 53.3 percent of the time on anchor (1,703 hrs.) [4].

The Changing U.S. Shrimp Market

Domestic shrimp production averages roughly 200 million pounds a year, so any growth in consumption beyond that level must be supplied by imported product. For decades imports have been a growing contributor to U.S. shrimp supplies. However, in 2001 the U.S. began receiving record volumes of low-priced, farm-raised shrimp which precipitated an industry-wide revenue crisis.

Using International Trade Commission data and the approach suggested by Pindyck, and Rubinfeld, tests were conducted to discern whether a structural change had occurred in the U.S. shrimp market beginning in 2001 [5,6]. Tests confirmed that a structural change in the annual growth of aggregate shrimp imports had, in fact, occurred. Between 1990 and 2000, annual shrimp imports grew by an average of 34 million lb. each year. However, between 2001 and 2008, the average, annual growth in import volumes more than doubled to 73 million lb. per year (Table 1, Figure 1). This structural change prompted two questions. First, what conditions precipitated these additional import volumes? Second, what has been the impact on shrimp fishermen as the market adjusted to absorb greater volumes of imported shrimp each year?

Table 1. Actual and Estimated Imports of Shrimp Between 1990 and 2008

Year	Total Imports	Model Estimate	Year	Total Imports	Model Estimate
1990	502,720,722	476,995,238	2000	762,241,410	815,389,110
1991	540,345,051	510,834,626	2001	884,038,244	849,228,497
1992	596,217,707	544,674,013	2002	947,828,331	922,024,944
1993	601,647,414	578,513,400	2003	1,113,221,681	994,821,391
1994	628,665,987	612,352,787	2004	1,143,025,131	1,067,617,838
1995	597,783,275	646,192,174	2005	1,173,411,807	1,140,414,285
1996	582,991,095	680,031,561	2006	1,307,439,526	1,213,210,733
1997	648,969,699	713,870,948	2007	1,231,998,906	1,286,007,180
1998	696,208,016	747,710,335	2008	1,249,102,162	1,358,803,627
1999	732,386,246	781,549,723			

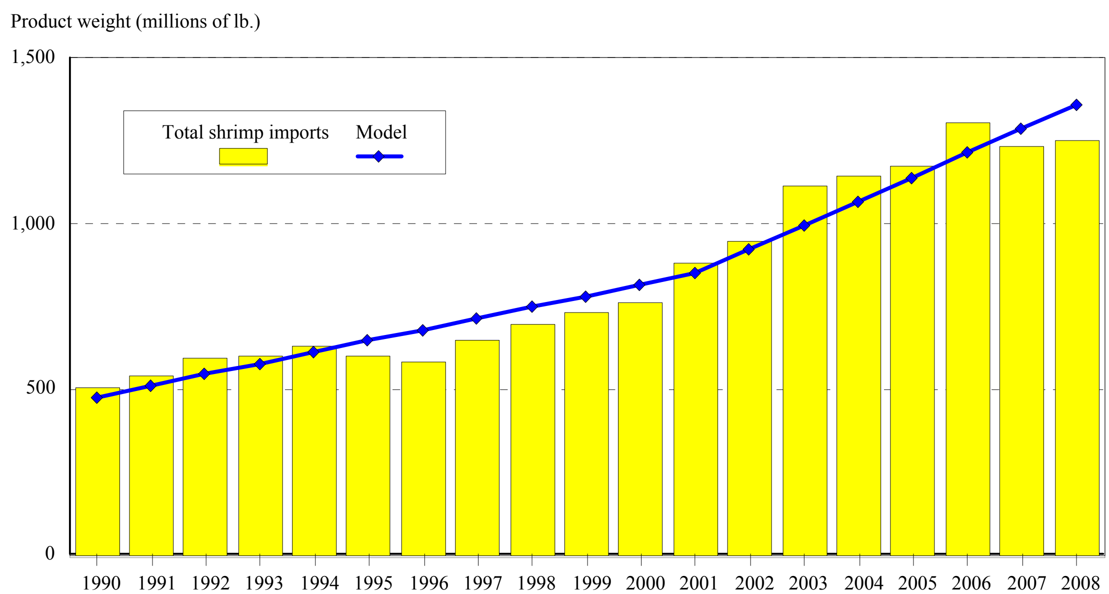

Figure 1. Actual and Estimated Total Imports of Shrimp Between 1990 and 2008

Conditions That Contributed to Additional Import Volumes. Sharp increases in U.S. import volumes resulted from four, unrelated conditions that occurred half a world away. First, various technological advances enabled rapid development of shrimp farms throughout South Asia, the Indian sub-continent, and Central America which increased the worldwide shrimp supply. Second, while shrimp farms were boosting world production, consumption of shrimp in Japan – historically one of the three largest worldwide markets for shrimp – stagnated due to a variety of internal, macroeconomic conditions [7]. Third, another major shrimp market – the European Union (E.U.) – sharply increased tariffs on selected shrimp products exported from Thailand in the fourth quarter of 2001 [8]. Increasing tariffs makes shrimp from affected countries appear less expensive in competing markets. Fourth, the E.U. also began strict enforcement of their food safety standards in 2001 which specified a zero-tolerance for farmed shrimp containing residues of banned antibiotics. Food safety authorities in the E.U. mandated **destruction**, of non-compliant product, not simply rejection.[6]

Thus, in two of the three major, worldwide markets for shrimp, Japan's demand had slowed while exporters to the E.U. faced a higher-priced environment along with daunting consequences for shrimp not meeting food safety standards. On the other hand, the U.S. – with a relatively strong economy and currency, no tariffs on imported shrimp, and a less aggressive enforcement of food safety standards – became the world's preferred export market for shrimp.

This *"Perfect Storm"* pushed record levels of relatively low-priced product into the American marketplace which significantly reduced local, dockside prices.[7] In 2003 imported shrimp exceeded 1.1 billion pounds (product weight) comprising roughly 88 percent of U.S. supplies, with farmed shrimp accounting for over half of total import volume. Four persistent conditions – growing worldwide supplies, sluggish Japanese demand for shrimp, newly applied tariffs on selected Asian shrimp imports by the E.U., and significant differences in administration and enforcement of food safety standards between the E.U. and the U.S. – left the domestic, warm-water, shrimp industry wondering how best to compete in a global supply chain that is rapidly being dominated by farm-raised shrimp.

Market Changes Necessary to Absorb Higher Quantities of Shrimp. As expected, reducing market prices has pulled more shrimp through the supply chain. Yet, those at the production level have seen dramatic reductions in ex-vessel prices. Between 2000 and 2006 the dockside price for large shrimp – under 15 count tails – dropped by 45 percent (i.e., $9.18 / lb. vs. $5.09 / lb.). Over the same time frame the ex-vessel price for medium-sized shrimp – 21 to 25 count tails – declined by more than 50 percent (i.e., $5.67 / lb. vs. $2.80 / lb.) while the producer price paid for small, young-of-the-year shrimp – 41 to 50 count tails – dropped by 58 percent (i.e., $3.94 / lb. vs. $1.66 / lb.). The $4.09 per pound price drop for large shrimp between 2000 and

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6. Food safety considerations are not new issues in the international shrimp trade. In the seventies and eighties, shipments from certain exporting countries were automatically detained pending sampling for bacterial pathogens. Today, the primary food safety issue is residue of banned antibiotics in farmed shrimp. For some shrimp-farming countries the food safety considerations in receiving countries have become much more important than tariffs or currency exchange rates in steering international trade. Expectations of regulatory oversight and scrutiny of incoming shipments for compliance with a country's food safety requirements can be the paramount issue in deciding where shrimp are sold; particularly if non-compliant product can be destroyed by the importing country's food safety authority.

   Beginning in August 2001, chloramphenicol, a broad-spectrum antibiotic was detected in shrimp offered for sale in the E.U. This compound has been banned in most countries for over a decade. With a zero tolerance for this compound, public health authorities in the E.U. blocked importation of non-compliant shrimp; much of it from China, Southeast Asia and the Indian sub-continent [9]. Citing the risk associated with sending potentially non-compliant shrimp to the E.U., Peter Redmayne, a columnist for Seafoodbusiness.com, noted in May 2002 that *"The European market for Asian shrimp is dead, since other Asian producers can't afford to risk having their containers seized and destroyed by E.U. regulators. As a result, shrimp that used to go to Europe is going to the United States, which is putting pressure on prices"* [9].

7. Keithly, et al. notes that world exports of shrimp grew from 900 million pounds in 1980 to 4.8 billion pounds by 2005. While the deflated value of these exports also increased, the deflated per-pound prices declined by about 50 percent between 1980 and 2005 [7].

2006 was dramatic. However, this size count historically has comprised just 3 percent of annual harvests so the impact on revenue is muted. Conversely, annual production of 21-25 and 41-50 count tails ranges from 21 percent to 35 percent of annual harvests, so the 50 to 58 percent drop in these ex-vessel price categories has created a major drag on revenue.

Industry response to eroding prices. With ex-vessel prices progressively declining in each of three subsequent years after 2000, the Gulf and South Atlantic shrimp industry filed petitions against six, major, shrimp-importing countries in late 2003. These countries included Brazil, China, Ecuador, India, Thailand, and Vietnam. The warm-water shrimp industry prevailed with their litigation, and tariffs were established for *virtually all* shrimp products imported to the U.S. by these six countries. However, with shrimp imported from over 100 countries, some trade diversion[8] and circumvention[9] occurred which muted the impact of the antidumping litigation upon local, ex-vessel prices.

Trade diversion can also occur as "named" countries switch their exports from so-called "subject" merchandise to "non-subject" merchandise [7]. Recall that *virtually all* shrimp products from the six, named countries were subject to tariffs. However, two of the twenty products that comprise the imported shrimp category – canned and breaded products – were not part of the anti-dumping litigation. As the tariffs took effect, huge volumes of "dusted shrimp" began arriving in U.S. ports. Importers noted that peeled shrimp, which were "dusted" with a light coating of flour, were a prerequisite to having the breading applied, and Customs and Border Protection apparently classified dusted shrimp under the ten-digit, Harmonized Tariff Schedule code for frozen, breaded shrimp [16.05.20.1020]. The historical record indicates that breaded shrimp products have always been a minor contributor to the entire shrimp import category ... until recently. Between 1990 and 2002, breaded shrimp imports averaged 2,239,988 pounds per year. Since 2003 however, breaded shrimp imports have averaged 70,039,591 pounds per year; an increase of thirty-fold. In percentage terms, between 1990 and 2002 breaded shrimp accounted for just 0.3% of total category imports. However, between 2003 and 2008, breaded shrimp accounted for 5.8% of total imports [10].

Shrimp Fishing Then and Now

Considered alongside other North American commercial seafood resources, tropical shrimp are an anomaly because they have been one of the few, if not the only, commercial stocks that have remained healthy and have not been over-fished. Shrimp are an annual crop, with yearly abundance determined by meteorological conditions that influence ecological parameters in the coastal bays where shrimp mature before they move offshore. Due to the health of the resource, fisheries managers never considered limiting entry to the Gulf and South Atlantic shrimp fishery.

Although the resource has remained healthy, shrimp fishermen have historically been caught in a unique set of operating conditions best characterized as *"landing a high-dollar product that provided a low profit margin."* In essence, the old adage of *"too many boats chasing too little product"* typically chiseled away at shrimp producers' bottom lines and their net worth in all but those years where "bumper" harvests were experienced.[10] Evidence of this can be gleaned from the Standardized Performance Analysis (SPA) of the

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8. Trade diversion is defined as imports from "named" countries (in an anti-dumping petition) being replaced by imports from "non-named" countries [7].

9. In the context of international trade, circumvention refers to the practice of an exporting country affected by tariffs to ship product to a third country unaffected by tariffs in the original receiving country so that the product can be packaged or repackaged with labeling from the unaffected country. Changing the originating country thus allows the product to the shipped to the original, final destination without any duty applied by the receiving country.

10. Between 1965 and 2006 producers experienced several extremely favorable annual harvests when production exceeded the 42-year average by more than 30 percent (i.e., 1967 with annual production 50% above the long term average, 1981 up 42%, and 2000 up 32%). In years with above average harvests, most offshore operators sharply boosted their net worth.

offshore shrimp fleet which was conducted between 1986 and 1997. At the median, this SPA indicated that \$0.9524 was necessary to land a dollar's worth of shrimp [3]. This left little room for the trawling enterprise to weather declines in dockside shrimp prices and/or increases in prices paid for inputs (e.g. fuel, repairs and maintenance, etc.).[11]

Between 2001 and 2005, annual production was sharply below the long-term average. Limited production coupled with relatively low prices for shrimp and increasing prices for inputs like fuel had a dramatic effect on fleet-wide effort. By the end of 2003, many vessel owners attempting to cover their vessel mortgage obligations had declared bankruptcy and exited the industry.[12] However, the exodus from the fishery did not stop in 2003. In 2006, annual, average ex-vessel prices for offshore producers were just 55 percent of what they were in 2000, but the average, annual unit price for diesel was \$2.12. Faced with continued low dockside prices and significantly higher unit prices for fuel, fewer offshore operators remained in the industry. Today federal resource managers note that fishing effort in the 10 to 30 fathom band across the western Gulf of Mexico has declined by 80 percent when compared against effort measured in that depth zone between 2001 and 2003.

Remaining operators have seen skyrocketing increases in catch rates – considered by many as the *"Holy Grail"* for a strong, profitable offshore production sector – but the expected economic benefits of more fruitful catches have not materialized because of historically low ex-vessel prices and the steady increase in input prices. Even with large jumps in catch per unit of effort, remaining producers face extremely tenuous economic circumstances. The current paradigm – *"large catches but with razor-thin margins"* – has changed the planning horizon of every operator in the fishery. Today, remaining operators are literally trying to survive economically to "fish another day." This day-to-day mind set forces managers and owner/operators to (a) adhere to time-worn procedures – even if they are incorrect or at best inefficient – and (b) forego any non-essential expenses. It also complicates an otherwise easy decision to invest in new technology that promises an immediate reduction in production costs like fuel, and instead turns that decision into an economic *"roll of the dice"* because some production may be lost during the time it takes to tune the new trawl gear for maximum effectiveness and efficiency.[13] Such a short planning horizon is one reason why our cooperative research efforts have taken additional time to complete, and were not as comprehensive as we had hoped.

Exploring The Fuel-saving Impacts Generated by Experimental Trawl Gear

This program, funded by SECO, was a structured outreach education and training program. However, helping shrimp fishermen reduce fuel consumption – classic outreach work designed to help producers meet objectives with fewer steps, less expense, etc. – required that we begin with outputs from a cooperative research program undertaken by elite producers. The performance data collected by these top-tier producers would serve as raw materials for subsequent education and training opportunities for remaining operators throughout the industry. The following segment outlines the steps required to design and implement the cooperative research work that enabled us to mount an aggressive outreach campaign. Ultimately, the cooperative research completed by elite producers and our efforts to summarize and communicate their results

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11. The twelve-year time frame for the SPA included seven years below the 42-year average harvest and five years above the 36 million lb. harvest, with only two years exceeding the long-term average by 20 to 22 percent.

12. The reduction in effort was disproportionately felt across the Asian-American community which had invested in offshore trawlers, but many of these trawlers were centered in northern gulf ports and focused on harvesting white shrimp, so the reduced numbers of operators was not evenly distributed across the Gulf of Mexico.

13. In July 2008 diesel prices reached their apex at \$4.02 per gallon. Using the \$7,000 cost of the new trawl gear and the documented fuel savings of 28 percent, an operator would recoup the cost of switching to the fuel-saving gear after burning 6,250 gallons of diesel; roughly the amount of fuel used over a single 15 to 20 day cruise.

to a variety of stakeholders (e.g., other industry operators, trade association executives, state/federal fisheries management personnel, and a variety of environmental non-governmental organizations) led to the impacts and "third-party initiatives" that complete this track of the report.

Locating, Testing, and Adapting Experimental Trawl Gear

In the late eighties Gary Graham – a project director and a professor in the Wildlife and Fisheries Sciences Department – began extensive industry evaluations with high-tensile-strength, small-diameter webbing, and found that these fibers were capable of reducing drag compared to nylon, the traditional webbing material used in the industry. The trade-off in opting for strong, small-diameter webbing was price. Spectra®, the small-diameter fiber with the highest tensile strength and abrasion resistance, was several times the price of nylon.[14] Today, Spectra® is a primary component in body armor used by the military, and the current unit price of approximately $80.00 per pound has made it prohibitive for use in the seafood industry. Another new fiber on the market called Sapphire® – a braided, high-density polyethylene – is also a small-diameter, high-strength, abrasion-resistant webbing material, but it is more reasonably priced.

Evaluation of proprietary webbing materials is part of the historical record of research designed to generate efficiency gains in the Gulf and South Atlantic shrimp industry. However, the evaluation of more fuel-efficient trawl doors has been a much more recent consideration. With unit fuel prices doubling from $1.00 to $2.00 per gallon between 2003 and 2005, industry leaders began searching for trawl doors capable of spreading nets to their maximum width, but with less resistance. The preliminary search ended with Icelandic trawl doors that, by virtue of their curved surfaces, create a differential in hydrodynamic pressure between the inside and outside surfaces which spreads the nets.[15]

Initial evaluation of these new cambered trawl doors began in 2005 (ahead of SECO and USDA funding) with *"proof of concept"* testing aboard the F/V Isabel Maier, one of the trawlers in the Western Seafood fleet headquartered in Freeport, Texas. Participants in those early sea trials were (a) Patrick Riley, General Manager of Western Seafood; (b) Captain Manuel Calderón, a forty-year veteran of the Gulf shrimp fishery and the most productive Captain at Western; and (c) Gary Graham. In initial sea trials, the experimental doors spread the nets typically fished by Captain Calderón, but the evaluation team noted several issues that needed to be addressed before these new doors could be considered as (a) viable replacements for traditional trawl doors on the Western vessels or (b) ready for other producers to evaluate. Subsequent testing and modification by Riley, Calderón, and Graham addressed these deficiencies.

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14. Leaders in the shrimp industry were quite enthusiastic about the benefits Spectra® webbing offered, but the relatively low cost of fuel made adoption among fleets, which employ Captains and crew to operate the vessel, lower than expected. When asked about their decision to continue using nylon, many cited the concern for such high-priced webbing that could become entangled in bottom obstructions and would be lost.

15. Historically otter trawls were opened with flat boards or "doors" made of wood or aluminum. Traditional trawl doors used in the shrimp fishery are flat. Flat doors generate spreading power by creating directed resistance in the water column as the vessel moves forward. This directed resistance is created with a four-point chain-connection system whereby the leading face of the door (i.e., that plane which faces the vessel) is attached so that (a) a face of the rectangle sits somewhat perpendicular to the sea floor and (b) the leading face of each door points away from the towing cable by an angle of about 30 to 45 degrees (known as the angle of attack). With flat doors, the nets are spread by resistance of the door created with the angle of attack as it travels along the seabed. While traditional flat doors are effective at opening the nets, the additional resistance necessary to spread the nets requires more RPM from the engine which, in turn, requires more fuel. On the other hand, vented, cambered (i.e., curved like an airfoil) doors spread the net by virtue of a hydrodynamic design similar to a airplane wing. To spread an identical net with a set of cambered doors requires just under half the geometric area found in a flat door. Furthermore, the angle of attack with cambered doors is significantly smaller than that required for flat doors. The combination of (a) a much smaller geometric area and (b) the reduced angle of attack sharply decreases resistance of the door which allows the engine to maintain a constant towing speed, but with fewer RPM.

Improvements from the initial sea trials included: (a) use of a smaller-sized door than originally expected, (b) replacing the curved "shoes" found on the bottoms of *"off the shelf"* doors (Figure 2) with flat "shoes" that resulted in more effective placement of net components on the seabed (Figure 3), (c) a bridle configuration that added vertical stability to the doors (Figure 4), and (d) design of a new sled with a buoyancy tank that slowed descent of the twin trawl system to the sea floor (shown in Figure 2 between the trawl doors and in Figure 5 during trawling operations).[16] From the early *"proof of concept"* testing and refinements made thereafter, the new vented, cambered trawl doors were ready for broad-scale testing by elite producers.

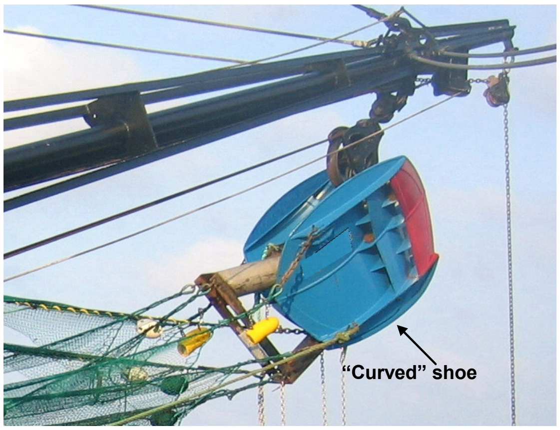

Figure 2. Original door design with a curved shoe that created instability during towing operations and an unacceptable shrimp loss

Figure 3. Retrofitted door with an "after market" shoe that increased stability on the sea floor and kept the net in contact with the bottom

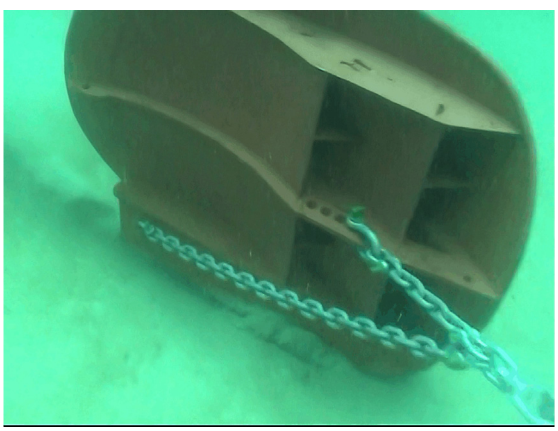

Figure 4. Cambered door showing bridle configuration attached to towing cable

Figure 5. Aft view of the sled with a buoyancy tank being towed between inside and outside nets

Cooperative Research to Evaluate Efficiencies of the New Trawl Gear

With SECO funding, the initial breakthroughs and subsequent improvements created with the vented, cambered doors in 2005 were subjected to broad-scale evaluation by elite fishermen along the Texas coast.

16. When two nets are towed on each side of the vessel, a sled or dummy door, is used as a third towing point, and is also connected to the head rope and foot rope of the inside and outside nets to expand the total opening of a twin trawl. Ultimately reducing the size of the sled and constructing it with flat bar has negated the need for a buoyancy tank to slow descent; now the flat-bar sled slowly "skis" to the sea floor.

SECO funds were used to purchase experimental trawl doors, Sapphire® webbing, and fuel-flow monitoring equipment. Project funds were also used to cover construction of nets.

This broad-scale evaluation phase had three objectives. First, fishermen who operate in different areas of the Gulf and South Atlantic were empowered to evaluate gear never before tested in their own "backyards" (i.e., the combination of (a) seabed conditions [mud or sand]; (b) water depth; (c) different net types and sizes for various targeted shrimp species; (d) various levels of horsepower, and (e) different, targeted shrimp species. Second, project directors anticipated that these elite cooperators would "spread the word" about the fuel-conserving nature of the new doors and braided Sapphire® webbing. The third objective was to create a cadre of "consulting elite fishermen" who could assist local fishermen with start-up problems associated with the new doors.

Using producer results, project directors were able to estimate a range of expected changes in fuel consumption other producers across the Gulf and South Atlantic may experience. The results of this cooperative research by fishermen enabled us to (a) produce various reference materials that summarized the findings of this effort as research results were generated and (b) conduct outreach training for Gulf and South Atlantic shrimp producers as well as other stakeholders (i.e., trade association executives, state/federal fisheries management staff, NGOs, other Sea Grant Extension staff, etc.).

Implementing a cooperative research project with industry required project directors to undertake a number of steps to ensure this pivotal aspect of the program came to fruition. Steps included: (a) design of the experimental methodology; (b) creation of a protocol for collecting performance data which resulted in a data-collection booklet; (c) identification of potential, cooperating fishermen; (d) specifying and ordering the complement of experimental trawl gear and fuel-flow monitoring equipment; (e) delivering experimental gear to cooperators; (f) assisting cooperating producers with troubleshooting activities; (g) summarizing cooperative research results; and (h) conducting outreach efforts.

Design of an Experimental Protocol

Project directors designed a four-step experimental protocol so that cooperators could collect information about engine RPM and fuel consumption during fishing operations in a standardized manner. In the four-step evaluation protocol, cooperators were asked to select a typical towing speed (i.e., ground speed or knot speed) for steps 1, 2, and 4 and attempt to maintain that speed across all steps that logged engine performance. Cooperators were encouraged to conduct all four steps when sea conditions were virtually "identical" so that one source of variation could be minimized among the different steps. Eight tows, each lasting at least 3½ hours, were required for steps 1, 2, and 4. For every tow across these three steps, each half hour the cooperator observed and recorded: (a) time of day, (b) actual knot speed (from the GPS), (c) RPM (from the tachometer), (d) fuel consumption (from the fuel-flow meter), and (e) sea conditions (such as **W**ith current, **A**gainst current, or **S**lack water).

- Step 1 reflects the cooperating producer's baseline for engine performance and fuel consumption. In step 1, cooperators logged RPM, fuel consumption, and sea conditions when they fished with their traditional trawl gear.

- In step 2 cooperators were asked to remove existing nets from their traditional trawl doors and replace them with new nets (of the same configuration and size as existing nets) made from small-diameter, braided Sapphire® webbing. Comparing results from this step with step 1 results quantifies the changes in RPM and fuel consumption that result from switching to nets made from high-tensile-strength, small-diameter, braided webbing.

- Step 3 focuses on generating equivalent production with both the cooperator's traditional gear and the new experimental equipment (i.e., the combination of nets made from Sapphire® webbing that are spread with the vented, cambered trawl doors). Step 3 required the cooperator to undertake fifteen, trouble-free tows while simultaneously fishing their traditional trawl system on one side of the vessel and the experimental gear on the other side. For the sixteenth through thirtieth tows, the locations of the experimental and traditional gear are swapped to opposite sides of the vessel. Swapping the gear halfway through step 3 is done to control for side-of-vessel production bias. The objective of this step was to reach production parity between traditional and experimental gear. This is a keystone step in the experimental protocol because given the tenuous economic operating environment, cooperators would not agree to pull a more fuel-efficient trawl if production suffered. The large number of tows was suggested to facilitate that minor tuning adjustments in the experimental gear so that it produced equivalently with the cooperator's traditional trawl. Additionally, thirty tows facilitates statistical analysis using the power of large numbers. This step did not require half-hour logging of fuel consumption or RPM data because the vessel was simultaneously fishing with two types of gear; each with different levels of resistence.[17]

- Once the cooperator was satisfied that the new gear could produce equivalently to his traditional rig, step 4 required that he fish the experimental gear on both sides and log knot speed, engine RPM, fuel consumption, and sea condition data. With this last step completed, project directors could compare RPM and fuel use among the producer's traditional trawl (Step 1), new nets made from Sapphire® webbing when opened with the cooperator's traditional trawl doors (Step 2), and new nets opened with cambered, vented trawl doors (Step 4).

Creation of the Data Collection Booklet

Developing the data collection booklet was an important task since a completed booklet was the only scientific record of the comparative analysis we would receive. Project directors designed the data collection booklet which cooperating producers could use to record the requested information every thirty minutes while fishing (Appendix I, pp. 34-39). Both English and Spanish versions were generated.[18] The booklet contained important reminder instructions along with various contact information. Booklet covers and those pages which separated each step were laminated while the pages which required the captain to complete were printed on waterproof paper. Some cooperators opted to record their data directly into a spreadsheet file.

Identifying Potential Cooperators, Ordering, and Delivering Experimental Equipment

Project directors attempted to spread the cooperative research efforts across various ports in Alabama, Florida, Louisiana, Mississippi, and Texas.[19] For the most part, project directors were successful in identifying producers interested in evaluating currently-used equipment and the experimental trawl gear while fishing. In choosing cooperators, directors also wanted to ensure that the testing was spread across the ethnicities found among the production sector, and with the original cadre of cooperating producers project directors identified, this objective was met. Project directors also contacted fishermen who had evaluated various

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17. Although step 3 did not measure fuel use, cooperating producers consistently noted that during this step, the vessel typically pulled toward the side with the traditional gear since resistance was greater on that side.

18. Early on we anticipated that a Vietnamese translation of the data-collection booklet would be necessary. However, the producers we thought would be interested in participating in the cooperative work ultimately "passed" on our offer. To date, no Vietnamese-American fishermen have conducted any experimentation with the vented, cambered trawl doors.

19. SECO funds were used to provide gear to Texas cooperators; USDA funds were used to provide gear to out-of-state cooperators.

environmental gear over the years. In this aspect of the project, the cooperator was the driving force in complete success or utter failure as far as adoption of the gear in particular ports was concerned.

After discussing the project with potential cooperators and getting their commitment, the doors, webbing, sleds (or dummy doors) and fuel-flow meters were ordered. Enough gear was ordered for each cooperator to outfit the vessel completely, even though the full complement would only be used in the fourth step. Each element in the complement of equipment was custom-tailored to each specific cooperator. For instance, there are several sizes of the vented, cambered doors available for shrimp trawlers. Selecting the proper size of the experimental gear required project directors and the distributor to make the conversion for potential cooperators. The first rule of thumb was to select a cambered door that represented roughly half of the area of the traditional flat door the cooperator historically used.

The size and configuration of nets also influenced the decision about replacement door size.[20] Braided Sapphire® webbing is available in different diameters, and discussions with the cooperator helped project directors select the diameter of Sapphire® with tensile strength similar to the webbing currently in use.

Depending upon when cooperators initiated the cooperative research project determined the type of sled they received. Some cooperators received sleds with the integrated buoyancy tank (Figures 2 and 5, page 9 above) while others received sleds manufactured from flat bar (Figure 6). Fuel-flow metering equipment is specifically designed for the main engine (both type and horsepower). Project directors had to be precise when specifying and ordering this experimental component because it was difficult to return an incorrect model to the manufacturer and would consume valuable testing time while another device was shipped.

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20. Cambered doors should be roughly ½ as long as current trawl doors, but net size, style, and webbing material also influence door size. For example, a 45 ft. nylon net requires 1.4m^2 doors but that same net made from Spectra® or Sapphire® can be spread with 1.1m^2 doors. Evaluation by elite fishermen suggest the following rules of thumb. If the producer currently pulls 4 – 40 ft. to 45 ft. nets, then 1.1m^2 doors should be used. If a producer pulls 4 – 45 ft. to 50 ft. nets, then 1.4m^2 doors should be selected. Sea trials of doors required to spread 4 – 50 ft. to 55 ft. nets are preliminary and suggest that 1.4m^2 doors are marginal at the 2nd tow point. Sea trials of doors required to spread 4 – 55 ft. to 60 ft. nets have not yet taken place. In summary, the size of door should be selected that allows nets to spread fully when the doors are pulled from the front-most towing point (which creates the smallest angle of attack). The smaller the angle of attack, the less resistance created which reduces the RPM necessary to maintain towing speed. Cost differences between door sizes (i.e., between 1.1m^2 and 1.4m^2 or between 1.4m^2 and 1.6m^2) are about $200 per set (or $50 per door) and is a minor issue. When in doubt, the next larger door size should be selected.

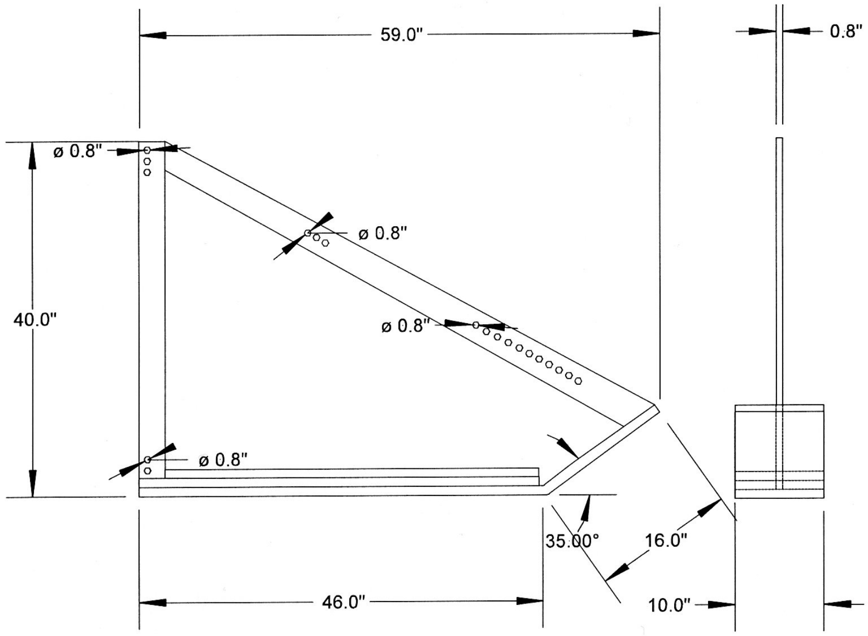

Figure 6. Trawl sled built from 1"x10" flat bar and ¾"x3" flat bar

The complement of experimental gear was personally delivered to each producer. While a time consuming part of the project, this gave project directors the chance to interact with cooperating fishermen and help them understand the protocol they were asked to follow.

Troubleshooting Activities

We were fortunate to have two early-adopting fishermen available as consultants to other cooperating producers who were experiencing trouble rigging the cambered doors since only a two-point bridle was used. Recall from footnote 15 (page 8) that traditional, flat doors require a four-point bridling system to establish (a) the angle of attack and (b) the "posture" or cant of the large face of the door to the seabed (i.e., the angle between the large towing-side face of the door and the sea bed). Virtually all of the consulting time was spent helping cooperators understand the rigging differences between their traditional doors and the experimental ones during step 3, the production parity step. This was the largest hurdle cooperating producers faced in moving through the four-step experimental protocol since the bridling system was foreign and even some elite cooperators were perplexed when trying to tune the doors so that (a) the new gear efficiently fished (i.e., determined after each tow by examining the condition of the shoes of the doors for shine, mud accumulation at the toe or heel of the door, etc.) and (b) the new gear produced on par with the traditional equipment.

Captain Louis Stephenson, owner-operator of the F/V Master Brandon, made trips to Tarpon Springs, Fl. (twice); Port Arthur, Tx.; Port Isabel, Tx.; Houma, La.; Bayou LaBatre, Al.; and Pascagoula, Ms. to assist cooperating fishermen having trouble tuning the new gear so it produced equally with the cooperators' traditional gear.[21] In every case where Captain Stephenson's expertise was requested by a cooperating fishermen, he generally spent two or three days offshore with the cooperator helping them tune the experimental gear until production equaled that obtained from the traditional equipment. Captain Stephenson

21. All of Captain Stephenson's consulting fees and travel expenses were covered with other funds. No SECO dollars were expended to conduct out-of-state work by anyone connected with this project. This includes project directors and consultants.

has also conducted several training sessions in Port Isabel, Tx and various locations in North Carolina, and Mississippi. Captain Manuel Calderón made one trip to the Rio Grande Valley to work with two fleets that quickly invested in the new trawl gear. We made more extensive use of Stephenson's expertise because he has a much more flexible schedule as an owner/operator than Calderón since his schedule is primarily set by Western Seafood, his employer.

Issues That Impacted Cooperative Research with Elite Producers

Historically, various experimental gear work with fishermen has occurred in the off-season (e.g., late fall, sometimes during relatively mild winters, and early spring). However, with all producers adopting a very pragmatic attitude about only fishing when expected abundance is high, we lost a large fraction of the off-season window typically used to evaluate new equipment. With the winter window all but closed, we had to find cooperators who were willing to evaluate the gear during peak production periods, but our list of potential cooperators dwindled because many were concerned about losing production and thus revenue during this time frame. This happened several times and forced project directors to locate substitute cooperators. Since the gear was specific to the original cooperator, some time was lost in locating a replacement cooperator, rerouting doors, webbing, and in some cases fuel-flow meters.

Project directors were mindful of the expense required for this broad-scale evaluation, and attempted to offer every chance for cooperators to be successful with this new gear. Directors were also mindful about the importance of the performance data being generated since that was the only scientific record from these trials. This precipitated four emphatic requests of cooperators.

- First, steps 1, 2, and 4 should be conducted when sea conditions are identical, or very similar! To get an accurate comparison of fuel use and RPM when fishing different diameter webbing and different doors at different times, as much variation as possible needed to be eliminated in sea conditions.

- Second, establish one towing speed like 2.8 to 3.0 knots and try to keep it constant throughout the study. This study compared the RPM and fuel required to push the vessel along at a pre-determined towing speed <u>in knots</u> when fishing with (a) traditional doors and existing webbing (Step 1), (b) nets made from Sapphire® webbing spread with traditional doors (Step 2), and (c) the experimental gear. (Step 4).

- Third, during trawling operations some change in towing speed, RPM, and fuel use is normal, so project directors asked cooperators to record <u>actual values</u> from the GPS (providing ground speed), the tachometer (RPM), and fuel-flow meter (gallons per hour). If towing speed is normally 2.7 knots, over the course of a 3½ hour tow it is reasonable to expect speeds from 2.6 to 2.8 knots.

- Fourth, every set of half-hour readings brings this project closer to measuring the benefits the new steel doors and nets made from Sapphire® webbing have on fuel savings across the shrimp industry. These readings are the only scientific information upon which we have to base estimates so directors implored cooperating fishermen to be accurate and complete with their data-logging activities.

Despite our requests, and the echos from our expert, consulting fishermen, some cooperators misunderstood basic requirements. There were two common problems. The first was holding RPM constant across steps 1, 2, and 4 as opposed to ground speed. Trying to work backwards with RPM as the independent variable is akin to using crop yield to predict rainfall. The second problem was producers not recording exact, observed values for variables like ground speed, but instead just writing their pre-selected speed for every half-hour observation. This pre-empted any analysis of variance.

Though some cooperators misunderstood our requests and produced data that were of limited value from a scientific standpoint, the anecdotal impressions of the gear and the individual making the claims had a huge impact upon adoption. The best example of adoption of this breakthrough, fuel-saving technology has occurred in the Rio Grande Valley; historically the home of the largest offshore shrimp fleet in the world. From a scientific standpoint, only two of three cooperators documented fuel savings. However, the top fleet manager in the combined ports of Brownsville/Port Isabel had a vessel chosen to evaluate the new gear (e.g., drawn from a pool of interested fishermen), and because of this manager's support for the project and the results (which were also verified by pre- and post-trip fuel-tank soundings) Brownsville/Port Isabel has seen a wholesale changeover to the new gear. However, the reverse is also true. A premature decision to abandon the project by one respected manager in another Texas port slammed the door on any other producer even trying the gear, and until late Fall 2009, not a single vessel in Palacios was pulling the new fuel-saving gear.[22]

Results from the Cooperative Research Process

Cooperative trawl gear research with elite producers was more akin to a series of case studies than a replicated evaluation primarily because no two cooperating producers had the same complement of characteristics which included (a) vessel horsepower, (b) vessel length, (c) net size and type, and similar operating environments. Importantly through these differences among vessels, nets, and areas fished were the real strengths of this work because the same gear was tested aboard differently-powered vessels, pulling different nets, across different water depths and bottom terrains. The cooperative research efforts demonstrated that the vented, cambered doors and the braided, Sapphire® webbing did, in fact, result in production parity while doing so with less fuel than the original gear pulled by the cadre of cooperators. Results generated by elite cooperators across the Gulf of Mexico suggest that other operators can expect somewhere between a 20 and 29 percent reduction in fuel use with the experimental fishing gear (i.e., somewhere between the 25th and 75th percentile values which comprise the middle half of the distribution) (Figure 7).

22. Beginning in October 2009, one fishermen in Palacios has moved from being a hired Captain to an owner/operator, and has converted to the new gear which was funded by the Sustainable Fisheries Partnership; one example of the third-party initiatives discussed in a subsequent section.

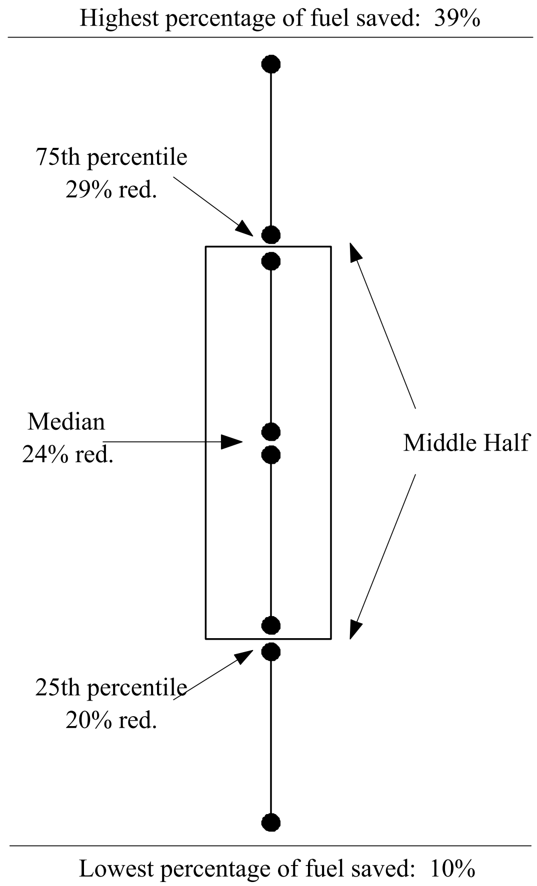

Figure 7. Fuel savings realized by elite producers who used the vented, cambered doors and Sapphire® webbing

Outreach Efforts to Support the Fuel-saving Trawl Gear Track

Outreach efforts were a key element in this track, and took numerous forms – from informal dockside meetings with fishermen to called workshops and formal symposia – with varied audiences that included producers (e.g., owner-operators, fleet owners, hired captains and crews), Sea Grant personnel, state regulatory officials, trade association leaders, and a variety of environmental non-governmental organizations (NGOs). The chronology of our outreach efforts are summarized in Table 2. The outreach efforts were substantial, and selected events are detailed in chronological order following the table. Every event organized by project directors or Captain Louis Stephenson provided attendees with a variety of reference materials that summarized our cooperative research efforts to date.

Table 2. Outreach Events Conducted about the Fuel-saving Trawl Gear

Event[a]	Location(s)	Date
Informal Dockside Meetings	Tarpon Springs, Fl. Brownsville, Tx. Port Arthur, Tx. Houma, La. Bayou LaBatre, Al. Pascagoula, Ms	01/2007 thru 08/2008
Meeting with La. Dept. Of Wildlife & Fisheries	Baton Rouge, La.	04/2007
Trawl Gear Symposium – Gulf States Marine Fisheries Comm.	Galveston, Tx	03/2008
North Carolina Trawl Gear Workshop Series	Supply, Snead's Ferry, Morehead City, Bayboro, Swan Quarter, Wanchese	04/2008
Trawl Gear Workshops	Venice and Empire, La.	04/2008
Meeting with Ms. Dept. of Marine Resources	Biloxi, Ms.	07/2008
Sustainable Fisheries Partnership	Brownsville, Tx.	08/2008
Brownsville/Port Isabel Shrimp Producers Assn.	Brownsville, Tx.	08/2008
Sustainable Fisheries Partnership	New Orleans, La.	09/2008
Sea Grant Researchers' Conference	College Station, Tx.	09/2008
Gulf & South Atlantic Fisheries Foundation	Tampa, Fl.	11/2008
Sustainable Fisheries Partnership	Houston, Tx.	11/2008
Ocean Conservancy	Freeport, Tx.	02/2009
Expert Working Group	Houston, Tx.	03/2009
Louisiana Sea Grant / LSU Ag. Center Trawl Gear Workshop	Intracoastal City, La.	04/2009
Southeastern Fisheries Association	Key West, Fl.	08/2009
Popular press: Seafood Business and National Fisherman		2009

a. Outreach events that are discussed following the table are shown in italics.

Informal Dockside Meetings

As the new gear was being distributed across the Gulf states, project directors and Captain Louis Stephenson conducted dockside workshops to explain the gear to cooperators and other producers interested in the new trawl doors. In addition, Captain Stephenson independently conducted meetings with producer groups in Tarpon Springs, Fl.; Brownsville/Port Isabel, Tx.; Port Arthur, Tx.; Houma, La.; Bayou LaBatre, Al.; and Pascagoula, Ms.

Meetings with the Louisiana Department of Wildlife & Fisheries

Commercial fishermen face numerous state and federal regulations that govern seasonal openings, net sizes, minimum mesh sizes, required environmental gear, maximum trawl door dimensions, etc. In Louisiana, state law specified a maximum height was specified for trawl doors. Unfortunately, this value was exceeded by the new cambered doors which are half as long, but a few inches higher that traditional doors. After his favorable experiences with the cambered doors in Terrebonne Parish, Captain David Chauvin approached the Louisiana Department of Wildlife and Fisheries about the possibility of a regulation change that would permit the use of the new trawl doors.[23] Captain Chauvin prompted a special meeting between the Louisiana

23. Captain Chauvin is a shining example of success generated through cooperative research. He completed the four-step experimental procedure, documenting a 27% reduction in fuel with the vented, cambered doors. He has become an advocate for this technology. Chauvin also helped troubleshoot connection problems that have prevented the gear from producing equally to traditional equipment. His willingness has resulted in many producers in Louisiana making the switch to vented, cambered doors. When project directors encountered him in March 2008, Chauvin had procured another set of cambered trawl doors for his second vessel. Project directors also learned that about forty shrimp fishermen in the Houma/Chauvin region have opted for the cambered doors which allowed them to remain on the water despite record fuel prices in 2008.

Department of Wildlife and Fisheries and Gary Graham in early April 2007. With fishermen and lawmakers by his side, the ideas presented in Graham's invited presentation became Senate Bill 20 which cleared the way for a regulation change (via a new state law) that increased the allowable height requirement thus clearing the way for widespread adoption of the new cambered, vented, fuel-efficient doors in Louisiana waters.

Trawl Gear Symposium – Gulf States Marine Fisheries Commission (GSMFC)

Project directors hosted a Trawl Gear Symposium and field trip at the March, 2008 meeting of the GSMFC in Galveston for regional Sea Grant fisheries staff as well as a variety of environmental non-governmental organizations (NGOs). This proved to be one of the most important outreach sessions conducted under this track of the project because it introduced the concept of *"environmentally-friendly"* fishing gear to various environmental NGOs. These NGOs would go on to undertake varied "third-party initiatives" to support changeover to more fuel-efficient gear used in the shrimp trawl fishery. These initiatives are detailed under the sub-heading "Third Party Initiatives" that begin on page 24.

North Carolina Fuel-efficient Trawl Gear Workshop Series

One of the attendees at the March, 2008 GSMFC in Galveston was Bob Hines, the North Carolina Sea Grant fisheries specialist. During our symposium, Bob asked about the idea of our conducting a series of workshops along the North Carolina coast to debut the new trawl gear to local shrimp producers. Ultimately, Bob organized five educational programs between April 21–25, 2008 in Supply, Snead's Ferry, Morehead City, Bayboro, and Swan Quarter, with a sixth workshop organized "on the fly" by project directors in Wanchese; the largest offshore fish port in North Carolina. Four individuals attended from Texas including Gary Graham, Mike Haby, Captain Louis Stephenson, and Patrick Riley – the General Manager of Western Seafood in Freeport and one of the pioneers who made the cambered doors work in the offshore shrimp fishery.[24] Some 80 fishermen and fleet owners attended, and interest in the new fuel-efficient gear was quite high.[25] Each workshop began with a 50-minute PowerPoint® presentation (Appendix II, pp. 40-55) with questions throughout, followed by a hands-on demonstration of the doors and how to bridle them by Captain Louis Stephenson, Gary Graham, and Patrick Riley. Workshop participants received a hand-out of the PowerPoint presentation and a DVD of underwater footage showing the performance of the vented, cambered doors taken in July 2007 off Panama City, Florida. Each workshop began around 5 p.m. with a presentation which was followed by the demonstrations which took place outside.

A formal evaluation was conducted after the workshop series ended via a mail survey (Appendix III, pp. 56-59). Answers to questions in the first section suggest that participants really increased their understanding of the new doors, but still needed more information about how to size the new doors so net spreading would equal what they were getting with traditional trawl doors (Table 3).

24. Getting a sample of the new cambered trawl doors to North Carolina to demonstrate the connections was deemed essential. Less-than-truckload round trip freight to haul a set of doors was about $1,000. At that point Patrick Riley volunteered to drive the doors over for the fee quoted by the low-bid common carrier. Patrick was a real asset to the workshop series, and his cooperative spirit made the logistics much easier since he was part of the presentation panel.

25. Importantly, the North Carolina shrimp industry is dominated by inshore operators who typically use less fuel. Smaller hulls with less powerful engines will extend the length of time necessary to pay for the doors with reduced fuel expense compared with a typical offshore Texas operator who can recoup the $7,000 cost of the doors alone with a single two-to-three week trip.

Table 3. Question 1 series: "Please check the box for each statement that best describes your impressions of this workshop."

I understand ...	Agree or Strongly Agree	Mean (Range 1-4)
the fuel savings other fishermen have experienced with this new trawl gear.	91%	3.45
how to connect the new doors to my towing bridles and nets so they will produce equally to the gear I normally use.	100%	3.30
how to troubleshoot improper connections between towing bridles, doors, and nets.	100%	3.30
how to determine the size of cambered doors needed to replace my wooden or aluminum doors.	78%	3

April was one of the busiest times of the year for this audience. Even though the workshops corresponded with the beginning of the Spring shrimp harvest, participants concurred that the workshop they attended was useful, informative, and important to them (Table 4). Attendance alone suggests that a high value was placed on participating because the discretionary time of these fishermen is so valuable in April. In some cases the Captain asked crew members to attend on their behalf. These individuals noted on the evaluation that the decision to switch to the new gear was not their decision. This reduced both the "agreement" percentages and the mean scores in the third and fourth questions in Table 4.

Table 4. Question 2 series: "Please check the box for the statement that best describes your thoughts about this workshop."

	Agree or Strongly Agree	Mean (Range 1-4)
Attending this trawl door and webbing workshop was important to me.	100%	3.36
The speakers and the demonstrations were informative.	100%	3.64
The information about these new doors and the braided Sapphire® webbing was practical to my operation.	90%	3.00
I can use what I learned in my operation.	90%	3.10
Overall, this was a very educational workshop.	100%	3.50

When asked whether they would review handout materials and watch the underwater DVD of trawl performance, all respondents said "Yes" (Table 5). When pressed about whether they would change to the new cambered doors, 78 percent said "Yes".

Table 5. Question 3 series: "What will you do with the information you received at the workshop you attended?"

	Percent (Yes)
I have (or will) review the handout material provided at the meeting.	100%
I have (or will) watch the DVD of how the fuel-saving gear performed.	100%
I will consider changing to the new cambered doors and Sapphire® webbing.	78%

The fourth series of questions asked respondents' about their impressions of the workshop experience. Fishermen appeared quite pleased with the workshop and demonstration. The results show that the presentation, though highly ranked by participants, was really just a *"warm-up"* for the demonstrations. In essence, fishermen wanted to get their hands on the new doors (Table 6).

Table 6. Question 4 series: "Please rate the quality of this workshop & demonstration."

	Good or Excellent	Mean (Range 1-4)
Slide presentation.	91%	3.18
Discussion & demonstration about properly sizing and rigging the new doors.	100%	3.18
Handout materials (copy of presentation & DVD).	100%	3.55

The final segment of the survey sought information about participants' operating conditions, and whether they had applied for Trade Adjustment Assistance in 2004 or 2005 (Table 7). Summarizing annual fuel consumption results provides little information since the audience was comprised of both inshore and offshore producers. As expected, the reported size of trawl doors currently in use demonstrated wide variation owing to the area fished. The average annual tenure as a commercial fishermen was high at 38 years in the business, and reflects the larger trend that few young people, not already connected to fishing, are choosing that line of work.

Table 7. Workshop Evaluation – Classification Questions.

	Mean
How many gallons of fuel do you burn each year aboard your vessel(s)?	12,300
What size are the trawl doors you now use?	Varies
How many years have you commercially fished?	38
Did you apply for Trade Adjustment Assistance in 2004 or 2005?	50% Yes

Our workshop reviewed results from other offshore operators in the Gulf of Mexico as well as two from the South Atlantic. Therefore, our results focused on the performance of doors larger than most inshore fishermen in North Carolina would use. One important outcome of our conducting the workshop series was interest among producers which precipitated North Carolina Sea to organize a cooperative research effort with inshore fishermen to explore the vented, cambered doors in the inshore shrimp fishery using other funding sources. In April 2010 project directors learned that funds had been acquired to conduct a broad-scale assessment of the new trawl gear in the various sounds (large embayments) along the North Carolina coast.

Meeting with the Mississippi Department of Marine Resources

After hearing about the North Carolina workshop series held in April 2008, biologists from the Mississippi Department of Marine Resources volunteered to organize a workshop similar to the one held in Baton Rouge the year before for Mississippi shrimp fishermen in late May just before their shrimp season gets underway. Gary Graham and Louis Stephenson conducted that workshop. Forty sets of reference materials (hand-outs and DVDs) were taken to the program, but attendance was approximately 120 producers. One key outcome from that meeting organized by the Department of Marine Resources was clearing another regulatory hurdle, thus allowing shrimp fishermen to use the vented, cambered doors in Mississippi waters. That new regulation took effect September 22, 2008.

Ocean Conservancy Videography about New Trawl Gear and By-catch Reduction Devices

In February 2009 Graham and Haby worked with Ocean Conservancy video staff and Western Seafood to highlight the new trawl gear and by-catch reduction devices required in the gulf shrimp fishery. This video clip was posted to the Ocean Conservancy's website and was shown continuously during the International

Boston Seafood Show held in March 2009. The Ocean Conservancy also posted the identical video clip to "YouTube."[26]

Expert Working Group (EWG) Meeting

In March 2009, project directors called a meeting of elite shrimp fishermen who participated in the cooperative research process to discuss the content, design, and distribution of reference materials for the larger industry. Elite producers came from Alabama, Louisiana, and Texas. This cadre of producers represented nearshore and deep-water operators, fishermen who worked in soft bottom in the western Gulf and those who fished the hard, sandy bottom off Florida's West coast during the winter for pink shrimp. The group was skewed towards the owner/operator with just one fleet owner in attendance.

This was an excellent two-day meeting, and the group addressed every question project directors asked. The EWG noted that with the wholesale changeover to the cambered doors and nets constructed from Sapphire® webbing in Brownsville / Port Isabel, they believed the reference materials did not need to be translated into Spanish. On the other hand, with no Vietnamese-American fishermen currently using the gear, the group thought that the additional expense of translating the reference materials in Vietnamese was warranted.[27]

One unanimous conclusion from the EWG was their willingness to appear on camera to review their experiences with the new gear, explain the results they generated, and outline any additional troubleshooting required in their particular circumstances. This would have been a powerful message for other producers who may vacillate about the decision to convert. The EWG also talked about additional research they would like to see that would quantify a variety of conditions that had not been subjected to testing such as fuel use at different towing points (which would create different angles of attack), minimum knot speed required to keep the doors canted perpendicular to the sea bed, the impact of clip-on flotation on fuel economy, etc.

Louisiana Sea Grant / LSU Ag. Center Trawl Gear Workshop

Graham and Haby traveled to Louisiana during April 2009 and met with offshore shrimp fishermen in, Dulac, Galliano, Golden Meadow, Intracoastal City, and Morgan City. Previously developed reference materials were updated with more recent unit prices for diesel fuel and distributed to producers throughout the week, and during the organized meeting in Intracoastal City; a large fish port with virtually all Asian-American operators. The presentation to roughly 40 operators was translated into Vietnamese by Ms. Thu Bui, Fisheries Agent with Louisiana Sea Grant and the LSU Ag. Center. These producers were extremely interested in the new gear because they use large vessels that consume about 30 gallons per hour.

During this meeting, project directors also discussed opportunities to conduct fuel-saving gear trials among the Vietnamese fishermen in Louisiana. The State of Louisiana is making funds available to help producers convert to less resistive fishing gear. Project directors were asked to comment about their experiences with the approach used in this effort. Assuming funds were available to do so, one of the issues that surfaced was using a very small cadre of elite producers, having production information available so compensation could be made for production shortfalls during the third step of the four-step experimental protocol. We also outlined some of the problems we had with our cooperative research efforts, though our Louisiana cooperator

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26. The clip is located at [http://www.oceanconservancy.org/site/PageServer?pagename=ftf_retailers_roundtable] and also on YouTube at [http://www.youtube.com/watch?v=E-2V1qe7pnY].

27. In the original complement of cooperating fishermen project directors identified one Asian fishermen in Palacios who expressed real interest in the new gear since he operated a large, twin-screw vessel that consumed over 30 gallons per hour. Ultimately, this cooperator fell victim to the *"roll of the dice"* condition outlined on page 7, and reneged on his commitment. Unfortunately, this operator was on track to test the largest cambered trawl doors offered to shrimp fishermen since his vessel pulled four 55 ft. – 60 ft. nets; the largest used in the offshore shrimp fishery.

funded by USDA, David Chauvin, provided some of the best information compiled in our gear research effort.

Southeastern Fisheries Association annual meeting

Gary Graham was an invited speaker at this regional association meeting in Key West during August 2009. He discussed the experiences and results from the multi-state cadre of elite producers who participated in the cooperative trawl door research.

Popular Press Articles

Graham was interviewed for two articles that featured the fuel-saving gear; one in *Seafood Business*[28] (June 2009), and the other in *National Fisherman* (November 2009) (Appendix IV, pp. 60-66).

Impacts Generated from the Fuel-saving Trawl Gear Track

Estimated Fuel Saving for Offshore Shrimp Trawlers in Brownsville/Port Isabel

From the information collected through a Standardized Performance Analysis (SPA) of offshore shrimp trawlers between 1986 and 1997, three percentile values for annual fuel use were computed [3]. These are reflected as the 25th percentile (58,775 gal.), the 50th percentile (66,101 gal.), and the 75th percentile (73,485 gal.). Table 8 (below) integrates three elements: (a) baseline fuel-use information between 1986 and 1997 collected as part of the SPA project, (b) documented fuel savings reported by an elite, Brownsville fisherman who participated in the cooperative research effort, and (c) two levels of gear adoption by the Brownsville / Port Isabel fleet. Biennial fuel consumption was reduced from baseline values to reflect savings that resulted from local experiences with the new cambered, vented trawl doors and Sapphire® webbing. These documented fuel-use savings rates ranged from 28 to 39 percent during experimentation with the new trawl gear between November and December 2007. Taking the more conservative value of a 28 percent reduction and using the 50th percentile in biennial, baseline fuel consumption of 132,202 gal., the individual trawler would save about 37,017 gallons when using the new vented, cambered trawl doors (132,202 gal. used before the switchover vs. 95,185 gal. with the new trawl gear). Using the computed, average, biennial unit cost of $2.478 per gallon (i.e., an average price of $3.173 per gallon for calendar 2008, and an average price of $1.783 per gallon for January – August, 2009) a trawler which used the median quantity of fuel would have reduced fuel expenditures by almost $92,000 (i.e., $327,597 in estimated biennial fuel expenditures generated with traditional trawl gear as opposed to $235,871 in estimated biennial fuel expenditures generated from the fuel-saving gear) (Table 8, Column 3).[29]

28. See [http://www.seafoodbusiness.com/archives.asp?ItemID=4056&pcid=267&cid=268&archive=yes] for the article.

29. The source for industrial No. 2 diesel prices can be found at [http://tonto.eia.doe.gov/dnav/pet/hist/d220300002M.htm]

Table 8. Biennial (2008-2009) Brownsville / Port Isabel Baseline Fuel Consumption and Reductions from Baseline Use Values by 28 and 39 Percent Which Were Documented by a Cooperating, Local Fisherman When Trawling with the Vented, Cambered Doors and Sapphire® Webbing

	Per-Vessel		Converted Vessels (132)		Entire, Local Fleet (165)	
	Gal. Used	Fuel Cost	Gal. Used	Fuel Cost	Gal. Used	Fuel Cost
Baseline[a]						
25th percentile (58,775 gal.):	117,550	$291,289	15,516,600	$38,450,135	19,395,750	$48,062,669
50th percentile (66,101 gal.):	132202	$327,597	17450664	$43,242,745	21813330	$54,053,432
75th percentile (73,485 gal.):	146,970	$364,192	19,400,040	$48,073,299	24,250,050	$60,091,624
28 percent reduction:						
25th percentile (42,318 gal.):	84,636	$209,728	11,171,952	$27,684,097	13,964,940	$34,605,121
50th percentile (47,593 gal.):	95185	$235,871	12,564,420	$31,134,633	15,705,525	$38,918,291
75th percentile (52,909 gal.):	105,818	$262,217	13,967,976	$34,612,645	17,459,970	$43,265,806
39 percent reduction:						
25th percentile (38,853 gal.):	71,706	$177,687	9,465,192	$23,454,746	11,831,490	$29,318,432
50th percentile (40,322 gal.):	80,643	$199,836	10,644,876	$26,378,003	13,306,095	$32,972,503
75th percentile (44,826 gal.):	89,652	$222,158	11,834,064	$29,324,811	14,792,580	$36,656,013

a. Baseline fuel use was documented from a Standardized Performance Analysis of the Texas offshore shrimp industry between 1986 and 1997.

Bracketing the savings from baseline consumption to the middle fifty percent of the overall distribution in annual diesel use, a producer at the 25th percentile would reduce his 2008–2009 fuel use by roughly 32,914 gallons (saving roughly $81,561 in fuel expense). A fisherman who experienced baseline fuel use at the 75th percentile level would see a 41,152 gallon reduction with the new vented, cambered doors and nets made from Sapphire® webbing. Over 2008 and 2009, dollar savings at the 75th percentile fuel use level would have been valued at just under $102,000.

During winter and early spring of 2008, Cameron County shrimp vessel owners made a "wholesale" change to the new fuel-efficient gear, with roughly 80 percent of the fleet (132 vessels) switching from their traditional flat, wooden doors and nylon nets to the vented, cambered doors and nets made from Sapphire® webbing. With an 80 percent conversion rate, the fleet-wide savings in fuel use and fuel expense when the median use value is assumed would be 4.88 million gallons valued at approximately $12.1 million for the two-year period (Table 8, Column 4). Considering the middle fifty percent of the distribution in historic fuel use, the new gear has saved Cameron County shrimp fishermen between 4.3 and 5.4 million gallons valued between $10.8 million (25th percentile in historic fuel use) and $13.5 million (75th percentile in historic fuel use) (Table 8, Column 5). Comparing such a high level of savings with the cost of the new doors – about $7,000 per vessel – producers who made the switch had "broken even" after burning several thousand gallons of fuel; about the duration of one fourteen-day cruise. The adoption of this equipment has occurred along a pathway very familiar to veteran Extension faculty; specifically, once industry "leaders" understand the significance of the results and make a commitment to change, others quickly follow suit.

Other Benefits Accruing from the Fuel-saving Trawl Gear

The experimental protocol presented on page 10 above suggests that fuel conservation was the primary objective of evaluating the vented, cambered doors which spread nets made from small-diameter, braided webbing. Fuel conservation and the reduction in fuel expense is, unequivocally, the largest saving attributable to the new gear, and it is immediate!. However, there are other preventive maintenance expenses that are a function of either engine service hours or throughput of fuel that are favorably impacted by using less resistive trawl gear.

<u>Reducing the frequency of oil and filter changes.</u> With less resistive gear, lower RPM directly translates into fewer service hours accumulating on the engine clock for each sixty minutes the engine runs. For example, a Caterpillar® 3412 operating at 1,800 RPM generates one service hour for every clock hour operated at that

speed. If RPM is reduced to 1,400 and operated for one hour, then 0.78 hr. (just over 45 minutes) would be added to the engine clock. The frequency of oil and filter changes – still the cheapest engine inputs – are governed by engine hours. Reducing RPM by 22 percent extends the required interval for oil changes to 514 hours of operation vs. 400 hours; a 28.5 percent increase in the interval between oil and filter changes. Changing oil and filters for a Caterpillar® 3412 currently costs about $350. For every 4,000 hours the engine operates at 1,800 RPM, ten oil and filter changes would be required; yet, were the engine running at 1,400 RPM only eight oil and filter changes would be necessary within the same 4,000 hours saving the owner $700.

Top-end engine overhauls. Caterpillar® recommends a top-end engine overhaul after 254,000 gallons of fuel are used. Computing the time interval between top-end overhauls can be done by knowing the annual gallons burned. From the SPA data, the median vessel used 66,101 gallons per year. This suggests that a top-end overhaul would be required every 4 years (254,000 gal. ÷ 66,101 gal./yr.) On the other hand with the new cambered doors and nets made from Sapphire® webbing, the vessel would burn 47,593 gallons per year (a 28 percent reduction in fuel consumption documented in Brownsville, Tx between December 2007 and January 2008) thus requiring a top-end overhaul every 5.5 years. At a cost of about $8,500, the owner would have spent $34,000 while using the traditional trawl gear and $17,000 had he switched to the fuel-saving gear. Thus, extending the interval for top-end overhauls by 1.5 years (37.5 percent) generates a 50 percent savings over the sixteen year assumed life of the engine.

Major engine overhauls. In addition to the top-end overhaul after every 254,000 gallons of fuel, Caterpillar® recommends a major engine overhaul after every 528,000 gallons are used. The approximate cost for this scheduled maintenance is $20,000. Using the same annual fuel use comparison as in the top-end overhaul example above, producers using their traditional gear would require a major engine overhaul about every eight years (528,000 gal. ÷ 66,101 gal./yr.). With reduced fuel use, owners who converted to the new gear would need a major overhaul every eleven years. After the same sixteen-year interval, scheduled major overhaul maintenance for the vessel towing the traditional gear would be $40,000 while the producer who converted to the new, fuel-saving gear would incur half that expense.

In summary, the new hydrodynamic trawl doors drive a variety of costs out of the enterprise by requiring fewer RPM to move the vessel forward during trawling operations. Reduced fuel consumption is the first and largest reduction accruing to the shrimp-trawling operation. Because of a slower-turning engine, RPM are reduced which, in turn, reduces the hours logged per clock hour of service. This extends the interval between oil and filter changes. Using less fuel also extends the interval between top-end and major engine overhauls which are governed by the amount of fuel consumed.

Third Party Initiatives

Our objective with this track of the program was straightforward: to reduce avoidable operating expenditures for offshore shrimp trawlers. However, as word spread about the success of this breakthrough trawl gear, other organizations expressed interest in helping to move the trawl gear *"changeover"* process further along. This work has blossomed into an effort with several facets which may help remaining operators overcome the economic crisis. These include (a) making credit available to producers who want to switch to the new gear and (b) using environmental protection and sustainability as verified, credence attributes associated with wild-harvested shrimp as a way to target domestic shrimp toward *"high-end"* users who are willing to pay a premium for seafoods harvested in an environmentally-friendly manner. The third parties and their activities are outlined below.

Shrimp Fishery Financing Activities Underwritten by the Sustainable Fisheries Partnership

The first called meeting of the Sustainable Fisheries Partnership (SFP) occurred in Brownsville during August 2008. The SFP is a roundtable of NGOs interested in providing incentives for sustainable, environmentally-friendly seafood-production practices. This called meeting was the first time the SFP had expressed any interest in working with the Gulf shrimp industry, and was a direct result of representatives attending the Trawl Gear symposium and field trip offered during the March 2008 Galveston meeting of the Gulf States Marine Fisheries Commission. At the Brownsville meeting, SFP representatives discussed the idea of providing low-cost financing to producers interested in switching from their traditional trawl gear to the cambered doors and Sapphire® webbing. Ultimately the Gulf of Mexico Shrimp Fishery Improvement Roundtable – a part of the larger Sustainable Fisheries Partnership – has developed a plan to offer the entire complement of fuel-saving trawl gear and a fuel-flow meter to producers at half price (Appendix V, pp. 67-68).[30] This is an important, first-of-its-kind opportunity for remaining producers since (a) most credit extended to the shrimp industry vanished with the advent of the revenue crisis and (b) converting to the fuel-saving gear requires roughly $17,000 per vessel.

At the second called meeting in Houston just before Thanksgiving, 2008, SFP leadership also expressed interest in moving forward with another financing opportunity, but this program would have a much greater cap that would allow that subset of producers who have been compliant with all environmental requirements access to significant pools of capital for much-needed deferred maintenance such as engine overhauls or new engines, hull and wheel (propeller) maintenance or upgrades. etc. Just as in the previous example, credit is a godsend to this industry since most producers have, out of necessity, been deferring maintenance for several annual cycles. At some point these deferrals must be addressed, else the vessel could be sidelined.

Texas Parks and Wildlife

The Coastal Fisheries Division of Texas Parks and Wildlife began promoting the new cambered trawl doors and nets made from Sapphire® webbing in Spring 2008 to Texas commercial shrimp fishery licenseholders (Appendix VI, pp. 69-70).

Support for Fuel-conserving Trawl Gear Research in Louisiana

The catastrophic damage and loss of life from Hurricane Katrina, galvanized many segments of the Louisiana economy into pro-active advocates for restoration and development. Huge sums await those segments that have prepared well-designed plans. The seafood industry is a case in point. Currently the Louisiana shrimp industry is designing a huge cooperative research effort to examine the benefits of the fuel-saving trawl gear which will include subsidized purchases of the gear, and a more aggressive system of compensating cooperators for losses during the start-up phase of their experimentation. This commitment is a direct offshoot of project directors involvement in that state's shrimp production sector that began with Graham (a) selecting David Chauvin as a cooperating captain to evaluate the vented, cambered doors and (b) helping the Louisiana Department of Wildlife and Fisheries rewrite their trawl door regulations to accommodate the vented, cambered doors. Graham fields several calls a week from program leadership about how best to pursue this large-scale cooperative research effort.

30. The first applicant for the"half-price" offer by the Gulf of Mexico Shrimp Fishery Improvement Roundtable to execute a trawl-gear switchover is in the port of Palacios. Another applicant is in the Northern Gulf and has been comparing the fuel used by one of our elite cadre of cooperators and the vessels in their fleet. The Gulf of Mexico Shrimp Fishery Improvement Roundtable program covers 50 percent of the total cost.

In addition, Mr. Robert Nguyen who works with LGL Ecological Associates, Inc. – one of the few regional, private environmental consulting firms working with the shrimp industry – recently reported that there are two very good Asian-American fishermen in Venice, La. who are asking numerous questions about acquiring the doors. These producers were exposed to them in 2008 when Graham conducted a by-catch reduction workshop in Venice and also discussed the impact the cambered doors were having on fuel conservation.

Eco-labeling Initiatives by the Sustainable Fisheries Partnership

Financing for the new gear and other vessel-related needs definitely peaked the interest of producers, many of whom have been internally funding critical refurbishment projects. However, SFP and the Marine Stewardship Council (MSC) are also in the process of conducting a preliminary assessment of the Gulf shrimp fishery to determine if it can meet the certification criteria for a sustainable, environmentally-friendly fishery. This preliminary assessment is being funded entirely by the SFP. MSC certification is considered the *"gold standard"* to firms interested in handling only sustainably-harvested seafoods produced in the most environmentally-mindful manner possible. The MSC certified the Alaskan salmon fishery several years ago, and has re-certified it within the last year. Documented fuel savings from the experimental fishing gear as well as virtual unanimous compliance with current state and federal regulations requiring a variety of environmental gear in shrimp trawls have made the relationship with the SFP and MSC possible.

Eco-marketing Initiatives

CleanFish® is an organization dedicated to supplying niches for seafoods produced in the most environmentally-friendly and sustainable ways possible. This marketing organization attended our trawl gear symposium during the March 2008 Gulf States Marine Fisheries Commission meeting, subsequently expressed interest in working with selected producers to market their products. The clients of CleanFish® are those firms who cater to customers with high expectations of environmental protection being factored into food production strategies. Beginning in September 2009, CleanFish® began working with selected, local shrimp producers to market wild, gulf shrimp harvested with the fuel-saving trawl gear to West Coast retail and food service establishments who handle sustainably-harvested seafoods. The shrimp prices quoted by CleanFish® have been much higher than those offered by the larger category market. This marketing breakthrough suggests that remaining operators may finally begin to grow their profit margins with the combination of higher dockside prices, historically-high catch rates, and reduced expenses for fuel.

Effectiveness of the Trawl Gear Track

SECO funding allowed project directors to put untested trawl gear in the hands of elite producers so they could undertake a standardized process of evaluating the new doors and webbing. As a result, we have documented a wholesale change to fuel-saving trawl gear in what was once the largest offshore shrimp port in the world: Brownsville / Port Isabel. The fuel-saving trawl gear track has generated dramatic savings while producing the same volume of shrimp as would have been harvested with fishermen's traditional gear. For producers, reduced fuel use immediately helps grow the margin between historically low ex-vessel prices and increasing unit prices for inputs.

When expressed in terms of dollars saved by the Cameron County fleet as a result of total SECO investment of roughly $76,000, project directors estimate that **for every SECO dollar invested, Cameron County shrimp producers alone realized a saving in diesel expense somewhere between $141.66 (25th percentile value in fuel use under a 28 percent saving) and $177.11 (75th percentile value in fuel use under a 28 percent saving).** This ratio does not include the savings generated from cooperating fishermen located in other ports or states, nor does it include cost savings from other groups of fishermen outside of Cameron County which would sharply boost the direct benefits of investment in the southeastern shrimp industry through the SECO program. The SECO fuel-conservation project, conceived, designed, implemented, and overseen by faculty jointly appointed to the Texas AgriLife Extension Service and the Sea Grant College Program at Texas A&M University, can take credit for fuel savings currently being generated in the shrimp trawl fishery.

Reduced fuel consumption has also opened several doors for the shrimp industry, primarily through a variety of third-party initiatives including (a) financing opportunities offered by the Sustainable Fisheries Partnership for compliant producers (i.e., those producers who use the mandated environmental gear in their nets such as turtle excluder devices and by-catch reduction devices), (b) the establishment of *"high-end,"* niche markets for sustainably-produced shrimp through Clean Fish®, and (c) undertaking an assessment to determine whether the Gulf shrimp fishery can meet the Marine Stewardship Council certification; a world-recognized, verified eco-labeling program. These initiatives are underway, but more time will be required before those efforts fully bloom.

Exploring Additional Fuel-saving Impacts Generated by a Skewed Propeller

History remembers early propeller technology as either stern-mounted paddlewheels used on the large river boats that plied the Mississippi beginning in 1811, or side-mounted, ocean-going paddle steamers that debuted around 1840. Today, advances in modern propeller technology are closely linked to advances in aeronautical engineering and hydrodynamics. With rising energy costs, owners of all types of vessels want to ensure that they are extracting the maximum efficiency per energy unit consumed. As well, vessel owners also want to ensure relative smooth, vibration-free performance.

Background Information About Propulsion Technology

Shrimp trawlers undertake two types of forward motion: free running and towing. Free running involves departing from port, returning to port, or traveling to other fishing areas. When the vessel is running, the fishing gear is either stowed on deck or is at least out of the water; particularly the trawl doors. Ground speeds for the running function are several times the ground speed maintained during towing. For instance, free-running speeds for the F/V Beth Lomonte averaged 8.1 knots per hour with the Kaplan-style propeller and 7.3 knots per hour with the skewed propeller. On the other hand, when the trawler deploys the fishing gear and focuses on catching shrimp, the resistance from the trawl gear requires significant pulling capability and necessitates a slower ground speed. Regardless of the propeller, during trawling operations, the F/V Beth Lomonte maintained a ground speed of between 2.8 and 3 knots per hour; much slower than during running.

In simple terms propellers are generally rated based on diameter and pitch. The diameter of the propeller impacts thrust or towing/pulling capacity while pitch is the theoretical, forward distance the propeller would travel in one revolution. Generally speaking, vessels that require significant speed typically are pushed along with relatively small propellers that have significant pitch. On the other hand, vessels like tugs and trawlers that require significant pulling power and operate a slower speeds typically use large-diameter propellers with less pitch. Propeller design has progressed to the point where a specific propeller can be designed for the required duty. Today, a single type of propeller (i.e., the variable pitch propeller) can accommodate both high-power pulling requirements; and with an adjustment on the console in the wheelhouse, can be re-oriented to provide relatively high-speed travel. Unfortunately, the unit itself and the controllers for such a propeller are extremely expensive and far beyond the reach of the offshore operator. Furthermore, the added utility of variable-pitch propellers is less important today since virtually all shrimp produced offshore is frozen at sea thus reducing the impetus to race back to port before the first signs of spoilage surface. Thus, fixed-pitch propellers are traditionally installed on shrimp trawlers.

With a fixed-pitch propeller, the designer has to weigh the relative fractions of total time the vessel will require significant pulling power versus running speeds and choose the unit that best accomplishes the primary objective. As previously noted, offshore shrimp trawlers operating in the brown shrimp fishery generally spend four hours fishing for every hour they run [4], so large-diameter wheels with less pitch are the norm.

While few, if any operators in the offshore shrimp fishery use variable-pitch propellers, this industry has been quite innovative in their adoption of proven propulsion technology that reduces costs. One of the most significant innovations adopted by the offshore shrimp industry has been the installation of propeller nozzles. Fitting propellers inside nozzles became a common practice across the Gulf and South Atlantic shrimp industry in the 1970s, and vessel owners claimed significant reductions in fuel consumption with the installation of nozzles.[31] Propeller nozzles – invented in the 1930s to prevent erosion of canal banks in Germany from prop wash – are here to stay in the shrimp industry because they provide so much more bollard pull than that created with a similar vessel relying on an open propeller.[32] Bollard pull is an important metric for the shrimp industry because trawlers spend a large fraction of time towing trawl gear as opposed to free running. Therefore, evaluative work with a skewed propeller also includes fitting the propeller inside a nozzle. The Kaplan-style propeller and the skewed propeller, each fitted inside the same nozzle, are shown alongside one another in Figures 8 and 9.

Figure 8. Kaplan propeller seated inside Kort nozzle prior to removal

Figure 9. Skewed propeller seated inside Kort nozzle (note wrench on shaft nut)

Results from a Performance Comparison of the Kaplan-style Propeller and the Newer, Skewed Design

When cooperative research with elite producers is conducted during the course of actual shrimp-fishing operations, sea conditions generate additional variation that can either magnify or mute treatment differences. This issue was mentioned on page 14 where we noted that cooperating producers should attempt to conduct all components of the trawl gear research protocol when sea conditions are about the same.

31. Side-by-side performance of trawlers with and without propeller nozzles conducted by Olds Engineering in Australia indicates a 16.4 percent reduction in fuel consumption when a propeller nozzle is used [11].

32. Olds Engineering in Australia conducted side-by-side testing of identical trawlers with and without propeller nozzles and found that the nozzled propellers generated 41 percent more bollard pull than the trawler with an open wheel [11].

Sea Conditions During Propeller Comparison Studies

Exploring the contribution the skewed propeller could make to additional fuel savings (i.e., beyond what the new trawl gear could offer) was conducted by one vessel already using the vented, cambered trawl doors and Sapphire® webbing. This vessel first measured various performance indicators (i.e., knot speed, RPM, and fuel consumption) along with sea conditions while fishing with the originally-installed Kaplan-style wheel (Figure 8 above). This data collection step began in mid-September 2007 and concluded in early November 2007; a period that generally exhibits less-harsh sea conditions than winter fishing. A frequency distribution of RPM generated during performance evaluation of the Kaplan-style wheel shows an approximate normal distribution (Figure 10). On the other hand, data collection with the newer skewed wheel occurred between the end of January 2010 and early March; a period characterized by stronger, heavier seas and faster currents; all of which require more power to maintain towing speed. A frequency distribution of RPM collected during the winter fishing season approaches a bi-modal distribution suggesting that the vessel had to work harder against sea conditions to maintain towing speed (Figure 11).

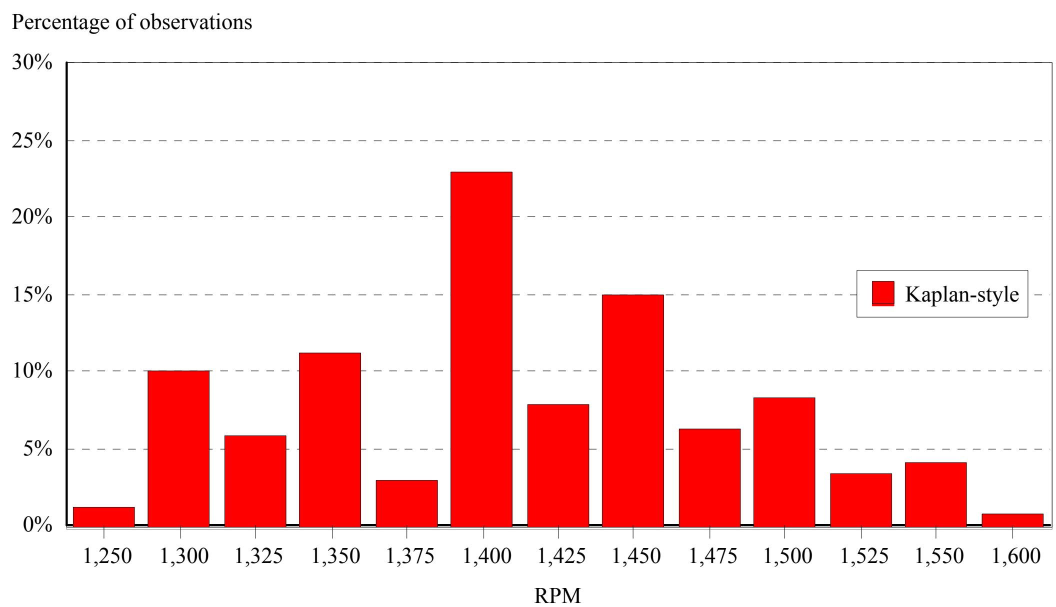

Figure 10. Frequency distribution of engine RPM collected during late summer / early fall with the Kaplan-style wheel while trawling

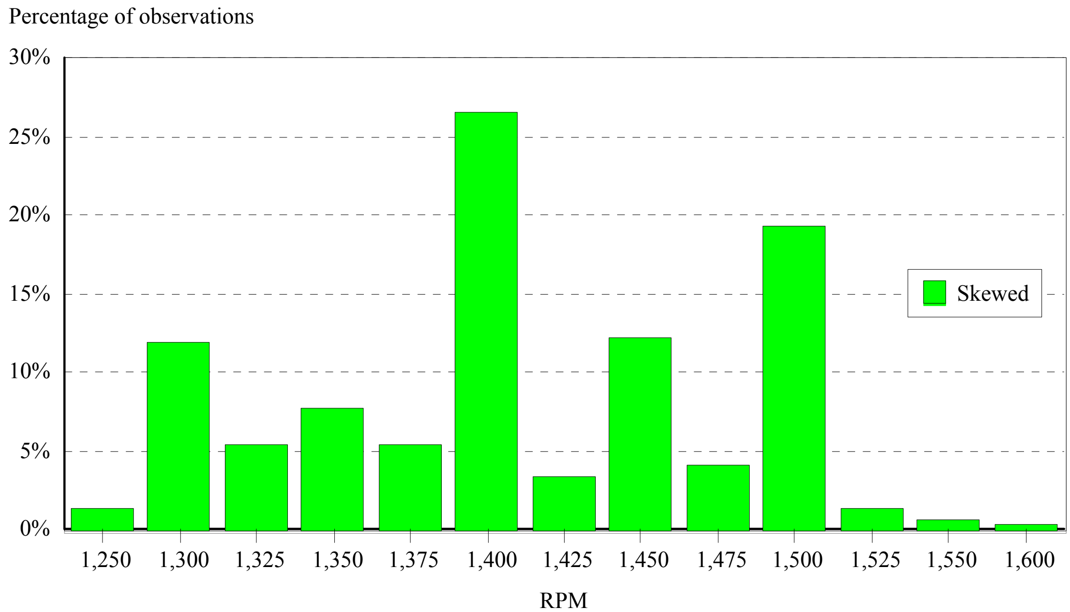

Figure 11. Frequency distribution of engine RPM collected during the winter with the skewed wheel while trawling

Findings

Measuring and comparing fuel consumption aboard the same trawler during fishing operations for both the Kaplan-style wheel and the newer, skewed propeller indicates a 0.9 gallon per hour reduction with the newer, skewed propeller (e.g., a grand mean of 14.8 gph generated with the Kaplan-style wheel vs. a grand mean of 13.9 gph generated with the skewed propeller). This 0.9 gallon per hour reduction amounts to a 6.1 percent decrease. Due to the different sea conditions when these data were collected, project directors believe that the computed, per-hour fuel savings rate is a conservative value. When fuel consumption (gallons per hour) is compared across the distribution of RPM required to maintain towing speeds between 2.8 and 3 knots per hour, fuel-consumption from the skewed wheel is consistently below that of the Kaplan-style wheel between 1,250 and 1,500 RPM (Table 9, Figure 12).

Table 9. A Comparison of Fuel Consumption (gallons per hour) Across Various Engine Speeds (RPM) During Trawling Activities by the F/V Beth Lomonte with a Kaplan-style and a Skewed Propeller

	Gal. / Hr. Towing – Kaplan Wheel					Gal. / Hr. Towing – Skewed Wheel				Skewed vs. Kaplan	
RPM	Count	Avg.	Min.	Max.	RPM	Count	Avg.	Min.	Max.	GPH Diff.	Pct. Diff.
1250	3	11.4	11.3	11.5	1250	4	10.1	9.9	10.3	-1.3	-11.4%
1300	24	12.3	11.3	13.7	1300	35	11.2	10.8	11.8	-1.1	-8.9%
1325	14	12.7	12.2	13.3	1325	16	11.8	11.4	12.2	-0.9	-7.1%
1350	27	13.3	11.5	15.0	1350	23	12.5	12.0	13.4	-0.8	-6.0%
1375	7	14	13.4	15.0	1375	16	12.8	12.5	13.2	-1.2	-8.6%
1400	55	14.4	12.5	15.6	1400	78	13.6	12.9	16.2	-0.8	-5.6%
1425	19	15.2	14.6	15.7	1425	10	14.5	13.9	15.8	-0.7	-4.6%
1450	36	15.6	13.3	16.4	1450	36	14.7	14.1	15.1	-0.9	-5.8%
1475	15	15.9	14.2	17.1	1475	12	15.4	14.6	15.9	-0.5	-3.1%
1500	20	17.0	15.0	20.0	1500	57	16.2	15.4	18.6	-0.8	-4.7%
1525	8	17.0	16.6	17.9	1525	4	17.4	16.9	17.8	0.4	2.4%
1550	10	18.6	17.5	19.6	1550	2	18.6	18.5	18.6	0	0.0%
1600	2	19.3	19.2	19.4	1600	1	21.2	21.2	21.2		

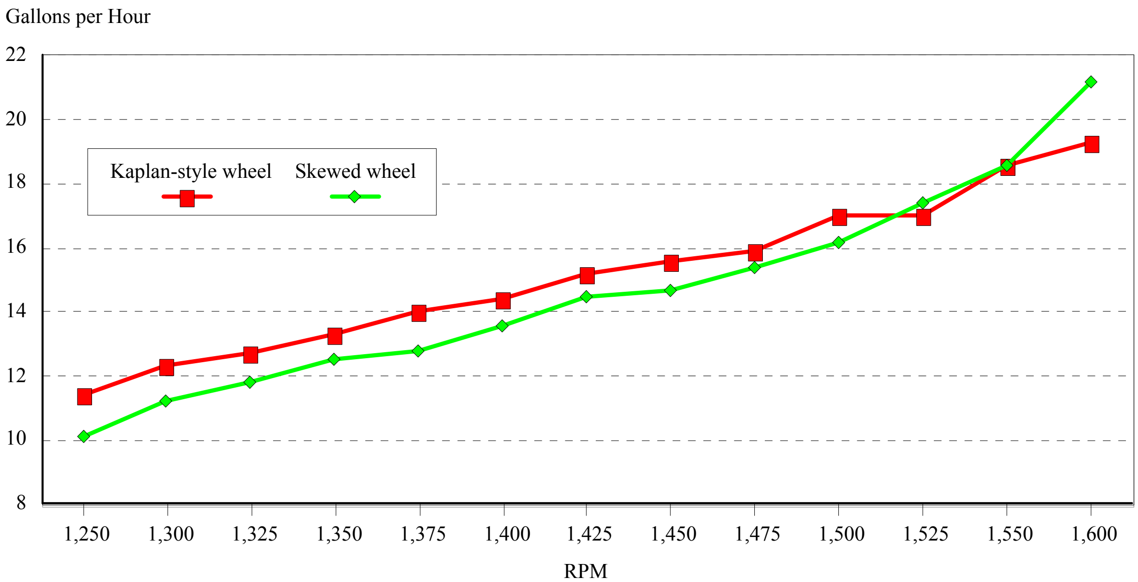

Figure 12. A Comparison of Fuel Consumption (gallons per hour) across Various Engine Speeds (RPM) During Trawling Activities by the F/V Beth Lomonte with a Kaplan-style and a Skewed Propeller

The Economics of Fuel-saving Technology

Capital budgeting is the process by which investment alternatives are quantified and ranked for funding consideration. Regardless of the size of the operation, not every alternative can be supported, so the capital budgeting process provides an objective way to identify those projects best suited for helping the operation in part determine its future with the investment dollars available.

Four issues determine whether the investment in fuel-saving technology makes economic sense. Cost of the new asset is the first consideration. A close second is the expected life of the new asset. The third issue is expected savings created by switching to the asset. The fourth consideration is the expected current and future unit cost of the input targeted by the investment – in this case fuel. For example, a low-cost, long-lasting conversion that generates large efficiencies in an input which is rapidly escalating in cost should "bubble" to the top of the list since it makes the most economic sense. Investments to achieve efficiencies through cost savings are repaid by less use of the input. When invested dollars are recouped after a relatively small amount of the input is used, this creates an extremely rapid return of the funds used to procure the new asset. On the other end of the spectrum, a relatively high-cost conversion with muted efficiencies will require higher throughput of the input before recouping the funds invested. In some instances, this may take several years.

Investing in Vented, Cambered Trawl Doors and Sapphire® Webbing

Trawl gear that can reduce fuel consumption between 20 and 29 percent when unit fuel costs range from $2.60 to $3.20 will require consumption of just a few thousand gallons (i.e., 13,462 gallons with a 20 percent efficiency improvement when the unit cost is $2.60 / gal. vs. 7,543 with a 29 percent efficiency improvement when the unit cost is $3.20 / gal.) before the investment in trawl gear is repaid (Table 10). Using the median, annual, fuel consumption value of 66,101 gallons for the sake of comparison, at the upper bound of efficiency and unit price, the investment would be repaid after using roughly 11 percent of the fuel historically used each year while at the lower bound of efficiency and unit price, the investment would be repaid after burning 20 percent of the annual quantity historically used. Recouping the acquisition cost of the more-efficient, longlived trawl gear within several months suggests that this investment should be among the first made by operators interested in driving avoidable costs out of the shrimp-trawling enterprise.

Table 10. Gallons of Diesel Necessary to Breakeven Given a Range in Diesel Prices and Savings of 20%, 24%, and 29% (computed 25th, 50th, and 75th percentile fuel-saving values)

Unit Price / Gal.	20% Reduction	24% Reduction	29% Reduction
$2.00	17,500	14,583	12,069
$2.20	15,909	13,258	10,972
$2.40	14,583	12,153	10,057
$2.60	13,462	11,218	9,284
$2.80	12,500	10,417	8,621
$3.00	11,667	9,722	8,046
$3.20	10,938	9,115	7,543
$3.40	10,294	8,578	7,099
$3.60	9,722	8,102	6,705
$3.80	9,211	7,675	6,352
$4.00	8,750	7,292	6034

Investing in the Skewed Propeller

At $16,500, investing in the skewed propeller (about $12,000 for the asset and roughly $4,500 for retrofitting by the shipyard) will require about the same total cost as the fuel-saving trawl gear (e.g., four cambered trawl doors, Sapphire® webbing for four nets, two sleds, and a fuel-flow meter). Based on current performance information, the new skewed propeller will shave an additional 6.1 percent off the operator's annual fuel requirements. At the median, this annual saving would amount to about 3,064 gallons.[33] With an acquisition and installation cost of about $16,500 for the new propeller, the time required to recoup the acquisition and retrofitting cost could be somewhere between 20 and 24 months depending upon the unit prices for fuel (i.e., [$16,500 ÷ (3,064 gallons x $2.60/gallon)] = 2.07 years or [$16,500 ÷ (3,064 gallons x $3.20/gallon)] = 1.68 years). For those assets which provide more modest efficiency gains and therefore require more time before positive cash flows materialize from the investment, the opportunity cost of investment capital must be carefully weighed and considered along with the time value of money to rank the costs and benefits of alternative capital budgeting projects.

Summary

Driving avoidable costs out of the production enterprise is a high priority for remaining operators since (a) shrimp prices plummeted in late 2001 (in response to a doubling of the growth rate in imported shrimp arriving in the American marketplace) while (b) input prices have increased. Achieving production parity between traditional trawl gear and the vented, cambered doors and nets made from Sapphire® webbing while reducing fuel consumption has been a significant reward for the industry. Unlike marketing efforts which require key ingredients of time and effort by the industry to affect a change in the price point of domestic shrimp, reducing fuel consumption is an individual decision that is relatively easy to achieve. Most Cameron County shrimp fishermen have adopted the new experimental trawl gear, and have collectively saved between 4.3 and 5.4 million gallons valued between $10.8 million and $13.5 million for the 2008 – 2009 biennial period. Current performance information realized from retrofitting the vessel with a skewed propeller showed

33. Beginning with the median, annual gallons of fuel of 66,101, but assuming that the investment in the trawl gear has already been made, the new skewed propeller would save the operator roughly 3,064 more gallons per year (i.e., [66,101 gallons used x (1-0.24)] = 50,237 gallons used with new trawl gear x (1-0.061) = 47,173 gallons used with the new trawl gear and the new wheel).

the asset can reduce fuel consumption beyond that achieved with the new trawl gear. However, without additional side-by-side comparison using two similar vessels – which could change the expected per-hour fuel savings – operators must have more patience when contemplating an investment in this asset.

Interestingly, reduced fuel consumption also impacts sustainability issues such as *"a reduced carbon footprint"* which were unheard of a decade ago but today immediately make shrimp harvested by fishermen pulling the new gear more attractive in that segment of the marketplace where environmental issues are an important credence attribute of the product. In Fall 2009, the first sales of shrimp produced with a reduced carbon footprint demonstrated a higher price per pound than the shrimp category average. This suggests that participating operators may finally be able to grow their profit margins with the combination of (a) historically-high catch rates coupled with (b) higher dockside prices and (c) less expenditures for fuel.

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Appendix I –Example Pages from the Four-step Data Collection Booklet

Comparing Fuel Consumption and Shrimp Production Using Traditional Trawl Gear and Advanced Equipment

Data Collection Tables for a Cooperative Study with Select Fishermen

Funding for this research and extension effort provided by the State of Texas Energy Conservation Office

SECO State Energy Conservation Office

Step 1. Establishes your baseline fuel consumption with the trawl gear you normally use (nylon or Spectra® webbing and wooden or aluminum doors) when pulled at your normal trawling knot speed.

Important Reminders:

1. Please use the same trawling speed for each tow.

2. Stabilizer deployment should be same for all tows; either in or out.

3. Please record information every 30 minutes for each of 7 tows that last at least 3½ hours.

Engine Make & Model: ____________________ Horsepower: ____________________

Location of your try net (please check one): ________ Port ________ Starboard Door dimensions: ____________________

Nets (Size & Material): ____

Tow	Elapsed Time	Date	Time of Day	Knot Speed	RPM	Gallons per Hour	With / Against Current	Notes / Comments
1	½ hr.							
1	1 hr.							
1	1½ hrs.							
1	2 hrs.							
1	2½ hrs.							
1	3 hrs.							
1	3½ hrs.							

Captain Xxxxxxxxx or Vessel Yyyyyyyyy Page 1 of 30

Step 2. Measures the proportional effect Sapphire® webbing used with your traditional trawl doors has on fuel consumption when pulled at your normal trawling speed in knots (the same knot speed used in step 1).

Important Reminders:

1. Use the same trawling speed **in knots** as in Step 1.

2. Stabilizer deployment should be same for all tows; either in or out.

3. Please record information every 30 minutes for each of 7 tows that last at least 3½ hours.

Tow	Elapsed Time	Date	Time of Day	Knot Speed	RPM	Gallons per Hour	With / Against Current	Notes / Comments
1	½ hr.							
1	1 hr.							
1	1½ hrs.							
1	2 hrs.							
1	2½ hrs.							
1	3 hrs.							
1	3½ hrs.							

Step 3. This step requires that you tune the experimental gear, then compare shrimp production generated when you pull your traditional gear on one side and the experimental equipment on the other, then swap sides and repeat the test to address side bias (a common approach used in evaluating shrimp loss with BRDs).

Important reminders:

1. Please use the same trawling speed **in knots** as you have in previous steps.

2. Shrimp production from four-rig trawls should be recorded from just the outside nets.

3. Shrimp production from two-rig trawls should be recorded along with try net production.

4. Good tows are those that are free of mudding, net/TED twists, tickler-chain fouling, torn gear/shark bites in bag, etc. If any such problems occur, then please do not do not record any results for that tow.

5. 30 good tows are required to compare production. 15 tows are required with the experimental gear on the port side and another 15 tows are required with the experimental gear on the starboard side.

				Traditional Gear		Experimental Gear		Try Net	
Tow	Date	Time In	Time Out	Side (P/S)	Production	Side (P/S)	Production	Production	Notes / Comments
1									
2									
3									
4									
5									
6									
7									

Step 4. Measures fuel consumption with the experimental doors and Sapphire® webbing when pulled at your normal trawling speed in knots

Important reminders:

1. For a meaningful comparison, use the same trawling speed **in knots** as you did in all previous steps.

2. Stabilizer deployment should be same for all tows; either in or out.

3. Please record information every 30 minutes for each of 7 tows that last at least 3½ hours.

Tow	Elapsed Time	Date	Time of Day	Knot Speed	RPM	Gallons per Hour	With / Against Current	Notes / Comments
1	½ hr.							
1	1 hr.							
1	1½ hrs.							
1	2 hrs.							
1	2½ hrs.							
1	3 hrs.							
1	3½ hrs.							

Appendix II – An Example of the PowerPoint® Presentation for Producer Meetings

Reducing Fuel Consumption in The Gulf & South Atlantic Shrimp Fishery

A presentation hand-out from the fuel-efficient,
cambered trawl door workshop.

Sponsored & Hosted by

Thu Bui – Fisheries Extension Agent
LSU Ag. Center & Louisiana Sea Grant Program

Prepared by

Gary Graham[1], Mike Haby[1], Patrick Riley[2] & Louis Stephenson[3]

1. Texas AgriLife Extension Service / Sea Grant College Program / Texas A&M University
2. General Manager of Western Seafood, Freeport, Texas
3. Owner-Operator FV Master Brandon, Hitchcock, Texas

Funded by (i) USDA/CSREES through the Intensive Technical Assistance Program, an outcome of participating in Trade Adjustment Assistance in 2004 and 2005 and (ii) the State Energy Conservation Office headquartered within the Texas Comptroller of Public Accounts

Fuel: Today the Largest Production Expense for Wild-harvested Shrimp

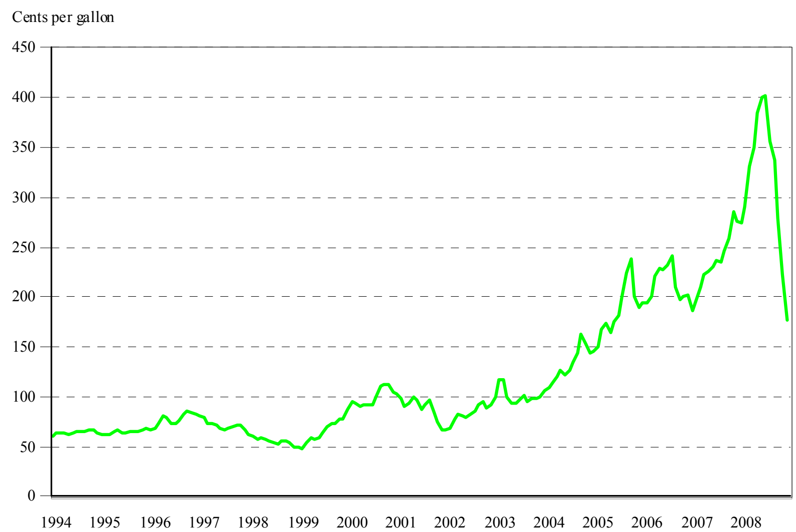
¦ Based on TAMU Standardized Performance Analysis of offshore Texas shrimp trawlers between 1986 and 1997, the median vessel used 66,101 gallons of diesel each year.

  ? In 1997 the cost for those 66,101 gallons was $49,576 ($0.75/gal).
  ? By 2006, the cost for that same quantity was $144,596 ($2.19/gal).
  ? Last year 66,101 gallons cost fishermen $209,765 ($3.17/gal).

¦ In 2006 roughly 40 percent of the 2,666 permitted offshore trawlers remained idle because of historically-high fuel prices & low dockside shrimp prices.

¦ In 2007, <u>days fished</u> across the Gulf in the 10 to 30 fathom range had declined by 78 percent when compared with the 2001-2003 base.

Nominal U.S. Industrial Price for No. 2 Diesel by All Sellers: 1994 – 2008



Source: http://tonto.eia.doe.gov/dnav/pet/hist/d220300002M.htm

Pioneers who found *"a better way"*

Counterclockwise from left: Patrick Riley and Captain Manuel Calderón – Western Seafood Co., Captain Louis Stephenson – F/V Master Brandon, Gary Graham – Sea Grant College Program

Traditional Trawl Doors and the Cambered, Steel Doors

AgriLIFE EXTENSION Texas A&M System

Sea Grant

Double-rigged, Energy-conserving Trawl System being Retrieved & Loaded

AgriLIFE EXTENSION Texas A&M System

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Work Began in April 2005 at Western Seafood in Freeport, Texas

¦ FV Isabel Maier – Captain Manuel Calderón
  ? Cat 3412
  ? Nozzle with Skewed Rice Wheel
  ? 4 – 47.5 ft. Two-seam Trawls
  ? Spectra® Netting
  ? Wooden doors 9 ft. x 40 in. (2.79 m^2) [9 ft. x (40 in. ÷ 12 in./ft.) x (1m^2 ÷ 10.76 $ft.^2$)]
  ? Burning 18.5 – 19 gph while towing @ 3 kt. (1525 – 1550) rpm

¦ Initial results
  ? Experienced difficulty in setting
  ? Doors laid in outward position
  ? After nights of adjustment, got gear to bottom & spreading
  ? Sled sank faster than trawl doors
  ? Adjusted leg lines
  ? No 4-point chain bridles – 2-point chain bridles

AgriLIFE EXTENSION Texas A&M System

Sea Grant

Positive Results from Initial Trials

¦ Initially evaluated 2.1 m^2 doors. These seemed too big. Settled on:
  ? 1.4 m^2 cambered doors
  ? Compared to the area of the 108 in. x 40 in. traditional flat door (2.79 m^2), the 1.4 m^2 cambered door is 50% smaller.
  ? 330 to 616 lb. with weight added.

¦ RPM were reduced from 1,525 to 1,400 (8%) while maintaining a 3 kt. towing speed.

¦ Cambered doors generated tremendous spreading power.

¦ Lead line and tickler 4 to 6 inches off bottom resulted in a 19% shrimp loss so the bottom of the doors were modified with a "flat" shoe.

¦ Added fuel flow monitoring system.

¦ Modified sled (dummy door) to slow descent to sea floor.

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Cambered Doors with “Factory” Shoes

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Cambered Doors with “Flat” Shoes Added

“After-market” Shoes

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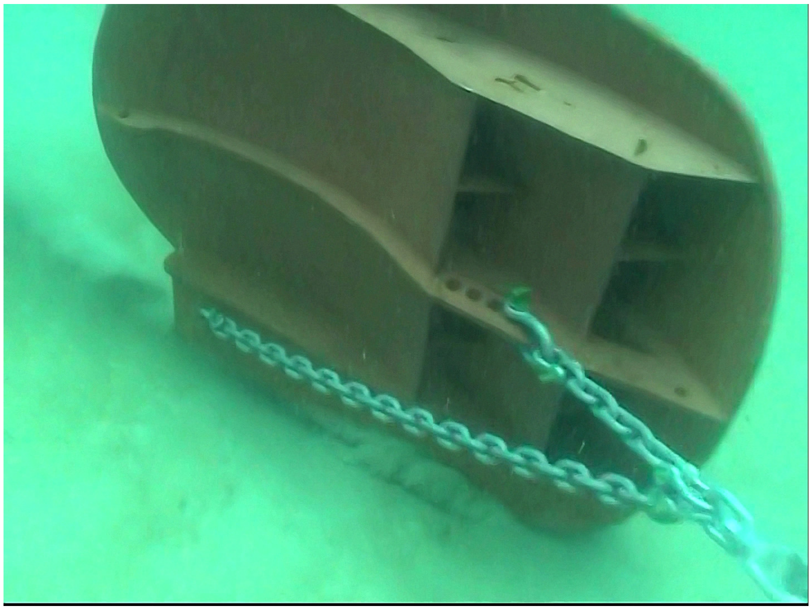
Chain Bridle Connected to a 1.1m^2 Door



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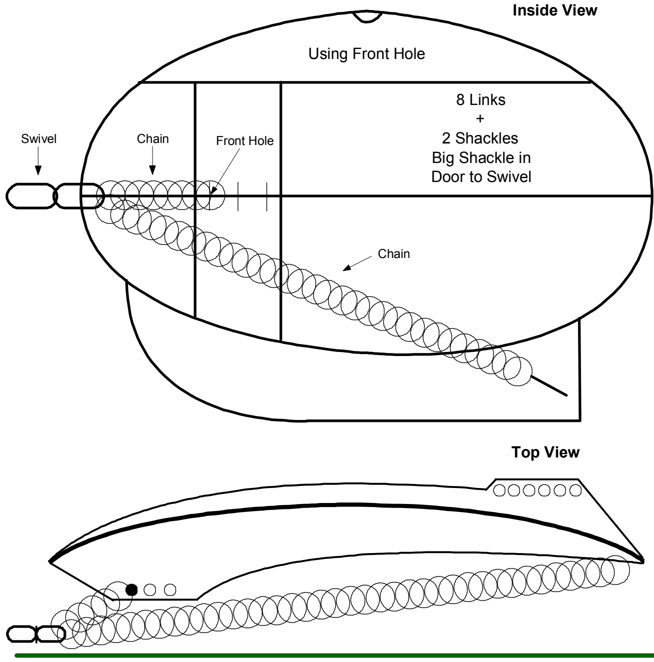
Bridle Configuration for 1.4m^2 Door (1)



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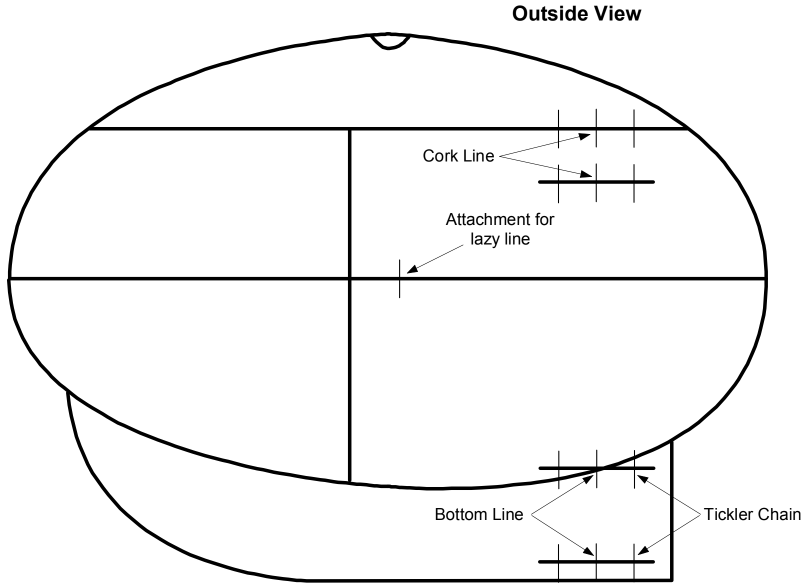
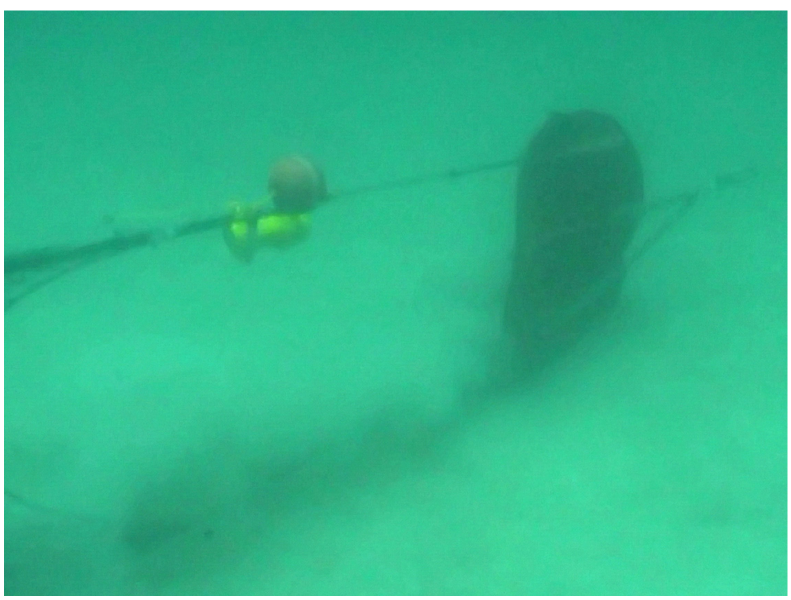
Net Attachment Positions for 1.4m^2 Door



AgriLIFE EXTENSION Texas A&M System — Sea Grant

Aft View of the 1.1m^2 Door with a 55 ft. Mongoose Net



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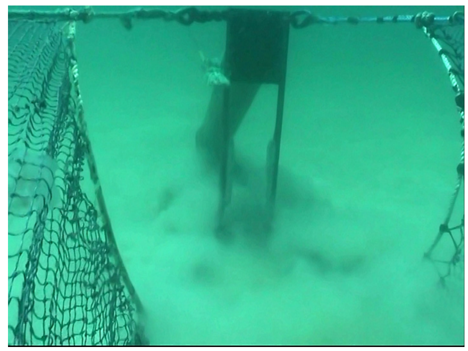
Two Views of the Sled in a Double-rigged Trawl System



AgriLIFE EXTENSION Texas A&M System — Sea Grant

Replacement Considerations for Cambered Doors

- Cambered doors should be roughly ½ as long as what you now pull, but net size, style, and material also influence door size. For example, a 45' nylon net requires 1.4m² doors but that same net made from Spectra® or Sapphire® can be spread with 1.1m² doors.
- Evaluation by elite fishermen suggest the following rules of thumb:
  - If you are pulling 4 – 40' to 45' nets, then use 1.1m² doors
  - If you are pulling 4 – 45' to 50' nets, then use 1.4m² doors
- Sea trials of doors required to spread 4 – 50' to 55' nets are <u>preliminary</u> and suggest that 1.4m² doors are marginal at the 2nd tow point. Sea trials of doors required to spread 4 – 55' to 60' nets have not yet taken place.
- Choose the door size that allows your nets to spread fully when the doors are pulled from the front-most towing point (the smallest angle of attack). <u>The smaller the angle of attack, the greater the fuel economy!</u>
- Cost differences between 1.1m² and 1.4m² & 1.4m² and 1.6m² doors are $50 per door, a minor issue. When in doubt, choose the next larger size.

AgriLIFE EXTENSION Texas A&M System — Sea Grant

Sapphire® Webbing

- Characteristics:
  - High-density polyethylene
  - Small-diameter, high-tensile-strength material
  - Fibers are braided, not twisted.
  - No dipping requirements like nylon webbing.

- Results:
  - Captain Manuel Calderón reports ½ to 1 gal. / hr. savings when comparing Sapphire® to Spectra®.
  - Captain Louis Stephenson reports 1½ gal. / hr. savings when comparing Sapphire® to nylon.
  - Captain Tim Adams reports 1 gal. / hr. savings when comparing Sapphire® to nylon.
  - Captain David Chauvin reports 1 gal. / hr. savings when comparing Sapphire® to nylon.

AgriLIFE EXTENSION Texas A&M System — Sea Grant

Moving from "Breakthrough" to Broad-scale Evaluation Across Industry

- Intensive Technical Assistance
  - Tim Adams – Bon Secour
  - David Chauvin – Chauvin
  - Gold Coast – Palacios
  - Juan Gaona – Brownsville
  - Eddie Garcia – Palacios
  - Bobby Pendarvis – Irvington
  - Jeff Vu – Palacios
  - Tom Williams – Tarpon Springs

- Texas Energy Conservation Office
  - Delbert Bull, Jr. – Sabine Pass
  - Charles Burnell – Brownsville
  - Manuel Calderón – Freeport
  - Frank Lasseigne – Brownsville
  - Ralph Rawlings – Matagorda
  - Marcelino Ochoa – Brownsville
  - Louis Stephenson – Hitchcock

AgriLIFE EXTENSION Texas A&M System — Sea Grant

Helping Cooperators Address the “Learning Curve” for Cambered Doors

- In more profitable times, most operators could experiment with the new doors and reach production equivalency.
- Today, such experimentation is economically impractical due to:
  - an abbreviated production window
  - record prices – on the high side for fuel and on the low side for outputs
- Elite Consulting Fishermen – Capt. Louis Stephenson (top) and Capt. Manuel Calderón (bottom) – have (i) helped the cadre of cooperators complete their 4-step protocols and (ii) sped conversion to this new gear.

AgriLIFE EXTENSION Texas A&M System

Sea Grant

Study Protocol for Evaluating New Gear

- Approach
  - Cooperator selects a <u>knot speed</u> and holds it (±) throughout all four steps
  - Each half hour the cooperator records:
    - Time of day
    - Actual knot speed
    - RPM
    - Fuel consumption (from the fuel-flow meter)
    - “Current” sea conditions (<u>W</u>ith, <u>A</u>gainst, <u>S</u>lack)
  - Eight 3½ hr. tows are required for steps 1,2, & 4.
  - 15 good tows per side are required for production equivalency step.
- Cooperator implements the approach across a 4-step procedure.
  - Step 1 – Baseline (current complement of nets and doors)
  - Step 2 – Sapphire® nets spread with traditional doors.
  - Step 3 – Side-by-side prod. equivalency (traditional vs. cambered)
  - Step 4 – Sapphire® nets spread with cambered doors.

AgriLIFE EXTENSION Texas A&M System

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Expected Benefits

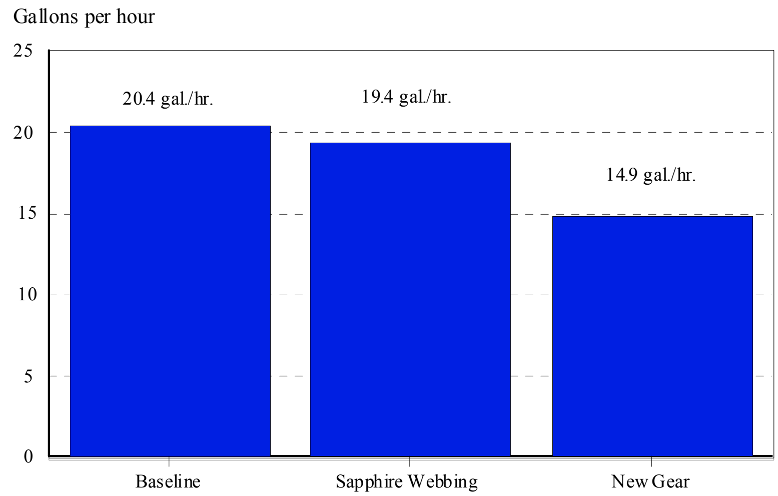
- Immediate economic benefit
  - The cambered, vented doors reduce resistance and require fewer RPM to generate desired towing speed. Across the offshore fleet, reported reductions in gallons per hour range from 10% to 39%!
- Engine maintenance
  - A slower-turning engine generates fewer "engine hours" than a faster-turning engine if run for the same amount of time. If operators follow prescribed maintenance based on "engine hours" then:
    - oil changes are required less frequently and
    - major overhauls occur less frequently. (Fleet managers estimate moving from an 8 to an 11 year interval.)
- Environmental stewardship
  - Cambered doors create a smaller "footprint" on the sea floor
  - Smaller carbon "footprint" with reduced fuel consumption

AgriLIFE EXTENSION Texas A&M System — Sea Grant

David Chauvin & The F/V Mariah Jade

AgriLIFE EXTENSION Texas A&M System — Sea Grant

Documented Fuel Consumption Aboard the F/V Mariah Jade across the Four-step Protocol (… a 5% & 27% reduction)



Summary & Conclusions (1)

- This new trawl gear generates immediate, significant fuel savings across offshore shrimp trawlers.

  ? **Sammy Snodgrass (fleet):** 375 hp. pulling 4 – 42 ft. nets reduced fuel use by 29 to 39%.

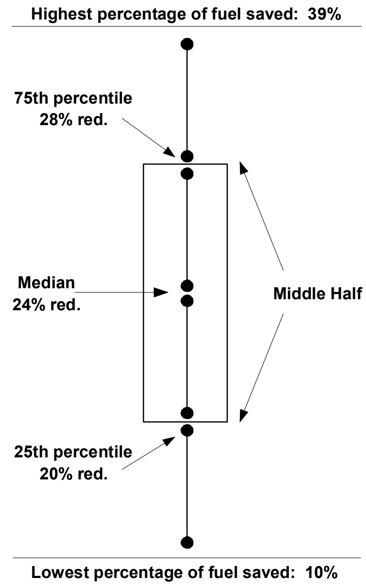
  ? **Western Seafood (fleet):** 500 hp. pulling 4 – 47½ ft. nets reduced fuel use by 28 to 33%.

  ? **David Chauvin, F/V Mariah Jade:** 300 hp. pulling 4 – 32 ft. nets reduced fuel use by 27%.

  ? **Louis Stephenson, F/V Master Brandon:** 500 hp. pulling 4 – 50 ft. 2-seam nets reduced fuel use by 20% inshore & 24% offshore.

Summary & Conclusions (2)

- Thus far, the total documented range in fuel savings is 10% to 39%. Consider the "middle half" of that range.
  - The median fuel-savings value is 24%.
  - 25% above and below that mid-point we find a 28% savings and a 20% savings.
  - This "middle 50%" of fuel-savings values (20% – 28%) is the range in fuel-savings most operators can expect!

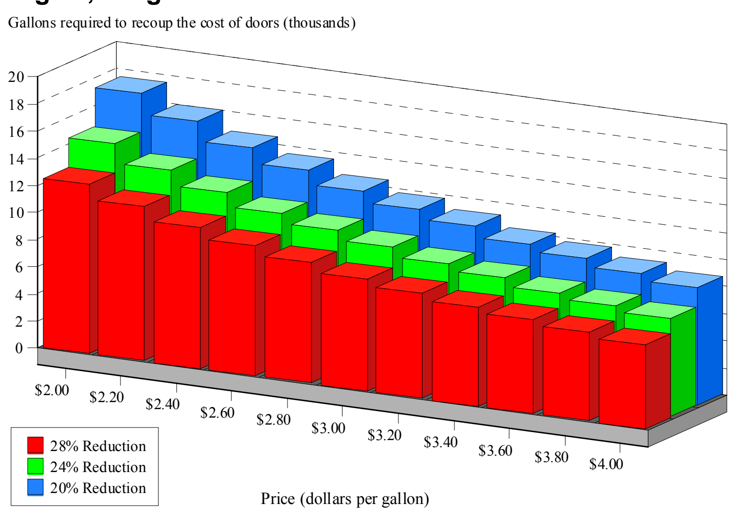


AgriLIFE EXTENSION Texas A&M System

Sea Grant

Summary & Conclusions (3)

- Four doors cost $7,000. With fuel @ $2.40/gal. and with a 20% reduction, you will recoup the investment after burning 14,583 gal.; with a 24% reduction after burning 12,153 gal.; and with a 28% reduction after burning 10,417 gal.



AgriLIFE EXTENSION Texas A&M System

Sea Grant

Summary & Conclusions (4)

Gallons you must use to pay for the doors given (i) different unit diesel prices & (ii) different levels of fuel saving within the "middle" 50 percent of reported savings by industry			
$ / gal.	20% Reduction	24% Reduction	28% Reduction
$2.00	17,500	14,583	12,500
$2.20	15,909	13,258	11,364
$2.40	14,583	12,153	10,417
$2.60	13,462	11,218	9,615
$2.80	12,500	10,417	8,929
$3.00	11,667	9,722	8,333
$3.20	10,938	9,115	7,813
$3.40	10,294	8,578	7,353
$3.60	9,722	8,102	6,944
$3.80	9,211	7,675	6,579
$4.00	8,750	7,292	6,250

AgriLIFE EXTENSION Texas A&M System

Sea Grant

Summary & Conclusions (5)

¦ Other benefits also accrue with more fuel-efficient gear.
  ? Engine-oriented benefits:
    ? More time between oil changes
    ? Can extend time between major overhauls from 8 to 11 yrs.
  ? Environmental benefits:
    ? Reduced footprint on seafloor due to shorter door length
    ? Reduced carbon footprint

¦ Cambered doors neither help nor hurt shrimp production. The new gear catches the same amount of shrimp but with lots less fuel!

¦ In certain ports conversion to cambered doors and Sapphire® webbing has been rapid. Roughly 80% of the Brownsville/Port Isabel fleet (132 vessels) has already converted to the new trawl gear.

¦ The search for efficiency is a journey … not a destination! This Spring we will evaluate the contribution a skewed wheel makes to fuel conservation while running and during trawling with the new gear.

AgriLIFE EXTENSION Texas A&M System

Sea Grant

Questions … Comments

AgriLIFE EXTENSION
Texas A&M System

Sea Grant

Appendix III – Producer Survey from the North Carolina Workshop Series

Texas Sea Grant Extension

Texas A&M University Sea Grant College Program ● Texas AgriLife Extension Service ● The Texas A&M University System

Texas AgriLife Research & Extension Center
10345 State Hwy. 44
Corpus Christi, Tx 78406-1412
Tel: 361/265-9203
Fax: 361/265-9434
E-mail: m-haby@tamu.edu

May 19, 2008

FIELD(1) FIELD(2) FIELD(3)
FIELD(4)
FIELD(5), FIELD(6) FIELD(7)

Dear FIELD(1) FIELD(3):

Several weeks ago we conducted a series of workshops about new trawl doors and braided webbing. These meetings were held to discuss and demonstrate a new type of door and low-cost braided webbing that is saving a significant amount of fuel (20 to 39 percent) with no decrease in production.

All of us – Gary Graham, Bob Hines, Patrick Riley, Captain Louis Stephenson and I – really enjoyed conducting the five workshops and we really appreciate your attendance.

We are constantly seeking ways to improve what we do for the seafood industry. I have enclosed a short evaluation to get your impressions of what we did, and how useful you feel our fuel-saving trawl gear workshop was to you. Would you please take a minute to fill out the evaluation and return it in the stamped envelope?

Thanks again for your participation. If we can answer any questions you may have about the doors or the braided Sapphire® webbing, please contact us.

All the best to you and yours,

Michael G. Haby
Professor & Extension Economist – Seafood

File: Cover-letter_NC-trawl-gear-workshop-eval.wpd

Attachments: Fuel-efficient_trawl-door_workshop-eval.wpd
Stamped, addressed envelope

Evaluation of the Fuel-efficient Trawl Door Workshop

held April 21 – 25, 2008

Your thoughts about this meeting will help us improve what we are doing. Please take a moment to answer these questions. It helps us make our work more valuable to you.

Please check the box for each statement that best describes your impressions of this workshop.

After attending this workshop...	Strongly Disagree	Disagree	Agree	Strongly Agree
I understand the fuel savings other fishermen have experienced with this new trawl gear.				
I understand how to connect the new doors to my towing bridles and nets so they will produce equally to the gear I normally use.				
I understand how to troubleshoot improper connections between towing bridles, doors, and nets.				
I understand how to determine the size of cambered doors needed to replace my wooden or aluminum doors.				

Please check the box for the statement that best describes your thoughts about this workshop.

STATEMENTS	Strongly Disagree	Disagree	Agree	Strongly Agree
Attending this trawl door and webbing workshop was important to me.				
The speakers and the demonstrations were informative.				
The information about these new doors and the braided Sapphire® webbing was practical to my operation.				
I can use what I learned in my operation.				
Overall, this was a very educational workshop.				

What will you do with the information you received at the workshop you attended?

PRACTICES	Yes	No
I have (or will) review the handout material provided at the meeting.		
I have (or will) watch the DVD of how the fuel-saving gear performed.		
I will consider changing to the new cambered doors and Sapphire® webbing.		

Please rate the quality of this workshop & demonstration.

	Excellent	Good	OK	Poor
Discussion & demonstration about properly sizing and rigging the new doors.				
Slide presentation.				
Handout materials (copy of presentation & DVD).				

Please tell us about you.

How many gallons of fuel do you burn each year aboard your vessel(s)?

_______________ GALLONS USED EACH YEAR

What size are the trawl doors you now use?

____

How many years have you commercially fished?

__________ YEARS

Did you apply for Trade Adjustment Assistance through the Farm Service Agency in 2004 or 2005?

_____ YES
_____ NO

Please provide any additional comments about this workshop in the space below. Thanks!

Appendix IV – Popular Press Articles from *Seafood Business* and *National Fisherman*

SeaFood BUSINESS

Shrinking the carbon footprint - June 3, 2009
Distributor focus on reduced carbon pays off; harvesters work to increase fuel efficiency
By Lisa Duchene

John Rorapaugh is working on a monster project, so far tackled only by a few in the seafood marketplace. Rorapaugh, who handles sustainability for ProFish, a Washington, D.C., distributor, is trying to place a carbon score upon each of the company,Äôs more than 700 products.

Called ,ÄúCarbon Fishprint,,Äù the labeling program takes into account criteria like whether the product is farmed or wild, the harvest method and gear type, its origin, the type of energy powering the production facility and whether the product was trucked or air-freighted.

Items accumulate points for carbon-intensity in each of the categories, up to a theoretical 50 points for an extremely high carbon-intense seafood product, says Rorapaugh. A Virginia croaker caught by hook and line is a ,Äúshining example,Äù of a low-carbon product, says Rorapaugh, and likely to score a six, while so far others deemed especially carbon-intensive like air-freighted Pacific bluefin tuna net a score of 38.

,ÄúI know that [carbon tracking is] the future,,Äù says Rorapaugh. ,ÄúI see it and Greg [Casten] and Tim [Lydon], both the owners, realize it.,Äù

Rorapaugh and ProFish embarked on the project for customer Bon Appetit Management, a foodservice company in Palo Alto, Calif., which two years ago launched an effort to cut the carbon footprint of its food supply by 25 percent.

That meant pushing its 30 seafood suppliers to provide information on how the seafood was harvested and transported, as well as how products compared on carbon dioxide emissions.

,ÄúThrough them, we started changing our buying practices,,Äù says Rorapaugh. The company is sharing carbon-emissions information with its other customers.

ProFish carefully orchestrates its truck routes for efficiency, purchases wind power for its warehouse, pushes suppliers to use recyclable cardboard instead of Styrofoam, and hopes to install mirrored tubes vertically along its warehouse walls to allow sunlight to fill the building and provide daytime lighting. Its goal is to become a carbon-neutral company.

The effort is just one example of how seafood,Äôs carbon footprint may be shrinking, although it,Äôs impossible to put a number on the current size or reduction. Assigning a carbon rating to a seafood product is hardly an exact science ,Äî something Rorapaugh is the first to admit. Yet, some measure of the carbon dioxide emissions represented by a product is becoming an important factor in the sustainable foods marketplace. Carbon dioxide is one of the greenhouse gases warming the planet. Today, atmospheric carbon dioxide concentrations are estimated to hover around 385 parts per million. NASA climatologist James Hansen advises a limit of 350 ppm to avoid ,Äúirreversible catastrophic effects,,Äù adding additional urgency to the effort.

In the Gulf of Mexico, and in waters off Maine and Alaska, fishermen are using energy-efficient practices and technologies to help save fuel costs. Fish feed companies are working on formulations to reduce the amount of fishmeal in aquaculture diets; less fishmeal tends to mean a lower carbon footprint.

Nearly all of the seafood Bon Appetit buys ,Äî an amount the company does not release ,Äî is transported by truck or ship, instead of by air.

Bon Appetit serves 80 million meals annually at 400 cafes in 29 states and since 2002 has been purchasing only seafood rated ‚Äúgreen‚Äù or ‚Äúyellow‚Äù by the Monterey Bay Aquarium Seafood Watch guide.

The company is 90 percent compliant with its goal to eliminate all air-freighted seafood, explains Helene York, Bon Appetit‚Äôs director of strategic initiatives.

‚ÄúFor us, the most interesting aspect of this initiative has been our work with seafood suppliers,‚Äù says York.

‚ÄúSuppliers are genuinely interested in trying to fairly represent their products as less carbon-intensive than other products.‚Äù

The key to cutting seafood‚Äôs carbon footprint is to use it regionally and seasonally because that approach cuts transportation-related emissions, says York.

On the water, there are several initiatives to reduce seafood‚Äôs carbon footprint. Record-high fuel prices of 2008 prompted many fleets to seek ways to cut fuel usage.

In the Gulf of Mexico, some shrimpers are saving between 10 and 28 percent with the use of new trawl doors, the weights that keep the net open and low to the bottom for catching shrimp.

The experimental doors were adapted from an Icelandic design, says Gary Graham, a marine fisheries specialist with Texas Sea Grant in West Columbia, Texas. The doors have squared bottoms and curved tops to reduce their drag in the water. The new design, first tested in 2005, costs about $7,000, comparable to traditional rectangular-shaped doors. But the design allows a 20 percent savings, or about 10,000 gallons of diesel fuel, off the typical Gulf shrimp boat‚Äôs average fuel use of about 50,000 gallons annually. Western Seafood, in Freeport, Texas, initially spotted the design in Iceland and has worked with Sea Grant and shrimpers to help adapt it for the Gulf, says Graham.

Fishermen out of Port Clyde, Maine, have also been testing various gear changes that reduce their boats‚Äô drag in the water and fuel use, says Steve Eayrs, a research scientist at the Gulf of Maine Research Institute. Some boats have lightened their sweeps, or rubber ground gear that keeps the nets off the bottom, and increased the mesh size in the cod-end of the net from 6.5 inches to 7 inches to reduce drag.

Eayrs plans this summer to measure the fuel savings the changes represent and encourages fishermen to install a fuel flow meter so they can see in real time how little changes saves fuel.

‚ÄúIt‚Äôs quite interesting that all these benefits can be realized by a relatively modest change in fishing gear,‚Äù says Eayrs.

In some parts of Alaska, the price of diesel fuel reached $7 per gallon in 2008. Most of the 126 fishermen who responded to a fall 2008 online survey from Sea Grant‚Äôs Marine Advisory Program said they had spent less time on the water prospecting for fish, stayed closer to home and stayed on the grounds longer. Many carefully planned routes, eased off the throttle and maintained their boat engines and fuel systems, according to the survey.

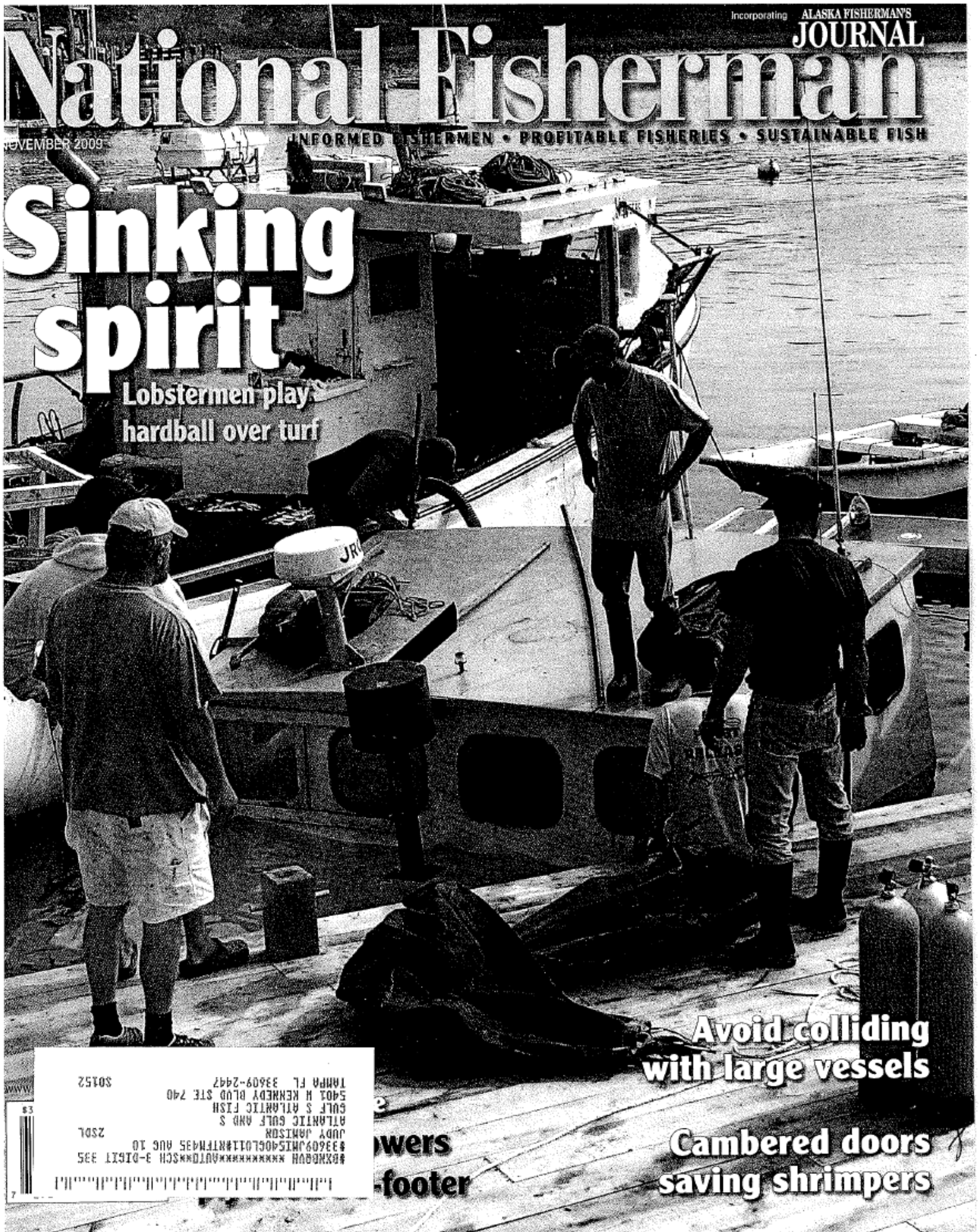
Glenn Haight, a fisheries business specialist with Sea Grant in Juneau, says his sense in talking with fishermen is that the changes will continue, even though fuel prices eased recently.

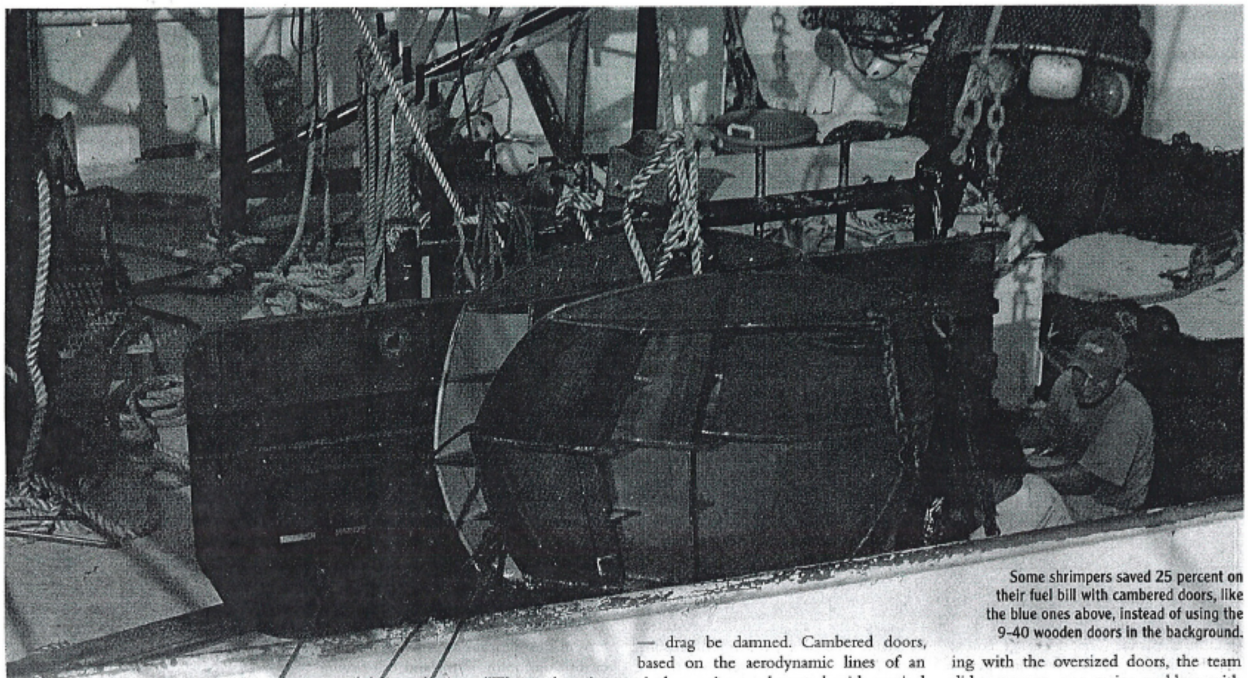
Perhaps efforts like those in Alaska, Maine and the Gulf will translate into value beyond saving money on fuel. Rorapaugh believes the information he is sharing with customers from his carbon-rating project has helped ProFish gain business in a dismal economy.

‚ÄúEverybody‚Äôs talking about down numbers and we‚Äôre not [down]. My sales have grown a lot this year,‚Äù says Rorapaugh.

Contributing Editor Lisa Duchene lives in Bellefonte, Pa.

June 2009


Incorporating ALASKA FISHERMAN'S JOURNAL
National Fisherman
NOVEMBER 2009
INFORMED FISHERMEN • PROFITABLE FISHERIES • SUSTAINABLE FISH
Sinking spirit
Lobstermen play hardball over turf
Avoid colliding with large vessels
Cambered doors saving shrimpers



Some shrimpers saved 25 percent on their fuel bill with cambered doors, like the blue ones above, instead of using the 9-40 wooden doors in the background.

Euro cash

European doors offer savings to southern shrimpers

By Robert Fritchey

Texas A&M University estimates that the state's offshore shrimpers each burn about 64,000 gallons a year. In 1997, at 75 cents a gallon, those 64,000 gallons cost $48,000. By 2006, the price for that same amount of fuel had nearly tripled to $2.20 a gallon or $140,000.

Caught in the crunch between high fuel costs and low dockside prices, roughly 40 percent of the 2,666 trawlers permitted to fish the offshore waters of the Gulf of Mexico stayed at the dock that year.

Then fuel really got expensive.

Luckily, the rising prices caught the attention of a Texas fleet operator who owns an oil delivery business. "We saw the price of oil start to run up, and from what was goin' on around the world, it wasn't gonna stop," says Patrick Riley, general manager at Freeport-based Western Seafood Co.

After visiting Iceland in 2001 and going aboard a large trawler, Riley became intrigued with fuel-efficient European cambered trawl doors. As he worked to adapt those steel doors to the Gulf of Mexico shrimp fishery, Riley brought Texas Sea Grant's Gary Graham on board. Graham not only helped with tuning the doors, but he introduced Riley to some new high-tech trawl webbing.

The use of cambered doors reduced the fuel consumption of Western Seafood's boats by about 25 percent without any loss of shrimp production. (Switching over to Sapphire netting saved another 3 to 9 percent.)

Getting there, however, wasn't easy. Graham characterized the initial trials for the trawl doors in 2005 as "sheer misery" and likened the experience to the advent of quad-rigged trawls in the 1970s. "When the four-rigs came out, it was rough," he says. "Then it took off."

Cambered doors have long been used to harvest finfish in Europe, particularly with midwater trawls. The oval-shaped boards glide over rough bottom more easily than rectangular boards, but the principle advantage stems from their hydrodynamic design.

While traditional flat and rectangular otter boards are relatively inexpensive, they're constructed to get that net open — drag be damned. Cambered doors, based on the aerodynamic lines of an airplane wing, and vented with vertical slots, are designed to spread a trawl while keeping resistance to a minimum. That increased efficiency allows the use of doors nearly half the size of traditional boards, as Riley and Graham found out.

Western Seafood's test boat, the Isabel Maier, had pulled four 47-foot 6-inch Spectra two-seam trawls, rigged with traditional 9' x 40" rectangular wooden boards, better known as 9-40 boards. The team initially tried a set of slightly smaller cambered doors.

As they're from Iceland, the doors are referred to in meters — 2.1-square meters in this case — not feet and inches, though for comparison sake, the wooden doors come out at 2.79 square meters.

But with the tremendous spreading power of the hydrodynamic boards, "It was very obvious that we had too much door. We didn't have enough load for the door to even make it respond right to the water," says Riley. "It took us about six or seven hours to get the doors adjusted just to be able to set them out."

While working with the oversized doors, the team did overcome one major problem with the sled, which in pair trawling holds the inboard wing of each net open.

"We were still using a sled for 9-40 boards and Gary figured out that it was sinking too fast. Out in deep water, you've got your twin rig [on each boom] and they're going out and the doors are completely spread. And you've got this sled in the middle that by the time it reaches the bottom, it might be 10, 20 feet below the trawl doors," explains Riley.

"Well, the net is holding the back end of the sled up, so basically when it reaches down you're driving the nose of it into the ground. That'll make for some nice effects sometimes, especially on a soupy bottom."

To slow the sled's descent, the team initially welded a length of thin-walled stainless pipe to the sled for flotation, but later determined that the same result could be

Captain Manuel Calderón helped make the new trawl doors work.

achieved by simply increasing the width of the sled's shoe.

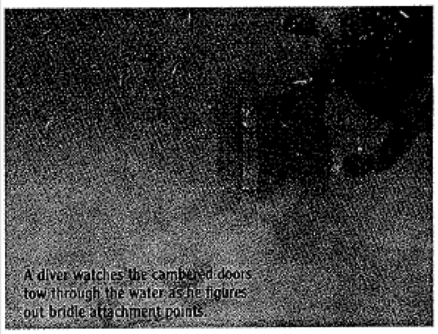
Upon hitting the dock, after the first tests, Riley ordered a smaller set of doors from Icelandic trawl-gear manufacturer Hampidjan. Manufactured in Spain, the doors had an area of 1.4 square meters — nearly 50 percent smaller than the original wooden boards.

Meanwhile, the Isabel Maier's captain, Manuel Calderón, had taken the 2.1-meter doors on a 24-day trip, "just to play with them," says Riley. "And he learned quite a bit.

The net was opening so wide, Reilly says, "He was catching rigs on either side of him.

"He picked up a lot of knowledge and it really paved the way for later on. If it weren't for him," Reilly says of Calderón, "I don't think any of these results would be here."

Indeed, when the new boards came in, "everything went off without a hitch," says Riley. "The doors just busted open, went down, and Gary and Manuel and I sat on the back deck and just looked at each other, dumbfounded. It was so easy.


A diver watches the cambered doors tow through the water as he figures out bridle attachment points.

"What it was — and it makes all the difference in the world — they were proportioned, the right size. The doors were loaded right and they operated fine."

With a fuel-flow meter, it had already been established that towing the 9-foot wooden boards at 3 knots, the Isabel Maier's 540-hp 3412 Caterpillar turned 1525 to 1550 rpm and burned 18.5 to 19 gallons per hour.

By comparison, with the properly matched cambered doors, 1400 rpm sustained a 3-knot towing speed and fuel consumption was reduced to 13.5 gallons per hour.

Continued on page 37

Alternative solutions

The cambered trawl doors that worked out for Western Seafood have failed to gain similar acceptance in some other ports, such as Palacios, Texas, where Craig Wallace runs a fleet of six boats.

After one of Wallace's captains tried the boards, "he called in after about two weeks and says, 'Look, I've done everything I could and liked to kill the crew deckin' these things. I can't make these things work.'"

Wallace's captain told him that whenever conditions changed, "Whether it be the current, or the roughness of the sea, he was takin' weight off, puttin' weight on, just doin' things to keep 'em workin' and it was workin' the crew to death."

"My guys do real well with the rigs they've been pullin' for so many years but if you start puttin' too much change on 'em it just causes a mess," Wallace says.

Though he's stayed with wooden doors, "which can be changed with a fence staple and pins," Wallace says that his fleet achieved a fuel savings of about 20 percent by altering those boards and switching from nylon nets to those made of high-density polyethylene Sapphire.

"And we're pulling 2 1/8 [-inch] mesh instead of 1 7/8," he says. "We pull 50-foot nets, so that's really been a big savings for us."

Wallace also reduced the size of his boards and widened the gap between the wooden slats on the doors, "so the water goes through the door better but it still gets a spread. And we've lightened up on our towing speed.

"We've been able to drop off 150 rpm, basically pulling the same net, but we used to pull 10-42 doors, now we're pulling 9-40s, so that's lightened our rig up. So that's kind of what we've gone to, to try to save fuel."

In hindsight, Wallace wonders whether the 1.4-square meter steel doors he tried matched his 50-foot nets, and acknowledged that his captains had only received dockside instruction in their setting and use.

— R.F.

and cultural presentations can be made.

Alvin Sibley, a builder of wooden boats, recently built a new bottom and installed a house and stern on an oyster boat for Ben Reynolds of Warsaw, Va., at Best Boatyard.

The boatyard is a relatively new facility on the Rappahannock River near Saluda, Va. Sibley put staving in the bow of the 26' x 7' wooden boat and then rebuilt the rest of the bottom.

The old staving was 3/4-inch-thick pine and the rest of the bottom was 1-inch pine. The wood that went back in was thicker 1 1/4-inch salt-treated pine for the staving and 1 1/4-inch wide-grain, short-needle pine planks for the rest of the bottom. "She's got nice lines, and with a thicker bottom, I think she will provide a more stable platform," says Sibley.

He also put in a new white-oak keel and shaped the stern with pine planks. Other work included a rebuilt shaft alley and new engine beds for a Chrysler inboard engine. — *Larry Chowning*

For contact information on companies in Around the Yards, see page 45.

Boats&Gear
Sustainability

Continued from page 33

After documenting the fuel savings, the team conducted shrimp production equivalency tests by pulling with the new steel doors on one side and the original wooden doors on the other.

In spite of the fact that Simrad equipment showed an increased door-to-door spread of 2.5 feet, at the minimum setting on the steel doors, the new rig produced nearly 20 percent less shrimp than the old setup.

"What we figured out is the shoes on these steel doors are oval at the bottom and the attachment point for the leadline was basically about eight inches off the ground. So that's what was killin' us," Riley says.

To bring the leadline down to the sea floor — especially important with bottom-hugging brown shrimp — the original shoe was replaced with a rectangular shoe, with an attachment point right on top.

Since the doors were originally built for fish trawls that have cork and leadlines of equal length, the attachment point for the towing cable was located directly in the center of the door.

With a bottom trawl, and its longer leadline, the doors tended to lean, which, again, pulled the leadline off the bottom. So the doors were further modified to accept a two-chain bridle set to check excessive spreading.

With the doors fully modified and tuned, final testing revealed an increase in the shrimp catch of about 2 percent.

The fully modified doors are now available through Marine & Industrial Specialties, a subsidiary of Western Seafood in Freeport. After having the boards manufactured in several locations, including in-house, the least expensive source proved to be China.

"What it's been able to do is allow these guys to afford them, at $6,500, $6,600 a set [of four] for 1.1s, 1.4s," says Riley, who says most of the Brownsville and Port Isabel, Texas, fleets had converted to the doors. "I know we've sold over 140, 150 boats worth down there."

While many fishermen could, within a season, work out the kinks in the new gear on their own, Sea Grant's Graham advises, "I wouldn't think of trying it without bringing an elite fisherman over to set you up."

Western Seafood's Manuel Calderón and Lewis Stephenson, of Hitchcock, are Texas Sea Grant's "consulting elite fishermen," who work with Graham to help fishermen along the Gulf rig up and troubleshoot the steel doors.

Grant money made it possible for the two skippers to travel to other ports. Graham says that the grant money would be used up by the end of August but he is applying for an extension.

Various other loans, grants and pilot programs are expected to become available in the gulf and South Atlantic states. Interested fishermen should contact their Sea Grant or state fishery agencies for details.

To help in establishing the grants, Sea Grant has sent its consulting captains across the gulf and South Atlantic coasts to set up other fishermen, and to reliably document their fuel savings under local conditions. Some of those results, and other information on cambered doors, are available in Texas Sea Grant's paper, "Improving Fuel Efficiency in the Gulf & South Atlantic Shrimp Fishery," on the Internet.

Also available online is a "A Cost-Benefit Analysis of Gear Replacement for Gulf Shrimp Fishermen." It was commissioned by the Ocean Conservancy and estimates payback times for converting to the new doors and trawls.

Texas Sea Grant is also working to develop an instructional video. **NF**

Robert Fritchey is at work on his second book, "Gulf Wars," about the net bans battles of the 1990s. He lives in Golden Meadow, La.

Boats&Gear
Safety

Continued from page 31

Gelinas adds.

At sea in the daytime, Johnson says there is a light area above the horizon and a dark area below the horizon. You'll find another ship on the horizon, but a small boat will be in the dark area. "It's much more difficult to pick out, so the first issue is just seeing it," he says.

And that's with good visibility. In fog or reduced visibility, it's that much more difficult to see a boat, notes Johnson, adding that "a lot of fishing boats don't show up well on the radar, especially with some wind and sea conditions. So I might not have any idea they are out there."

And speaking of limited visibility, a fisherman shouldn't make the assumption that a merchant ship is slowing down because it is foggy. "Merchant ships are out there to make money and you don't do that going slow. There pressure there to hold the speed," Johnson says. "Though as a pilot I slow down because the commercial pressures are less than safe navigation."

Chase notes that the "rules of the road" say to operate at a safe speed, "but they don't tell you how fast that is. I would say that most big ships run at sea speed through the fog."

Sea speed for merchant ships varies from 13 to over 20 knots. That's about 85 percent of the engine's output, says Johnson. Maneuvering speed is slower —10 to 11 knots. Once a merchant ship reaches open water it takes about 30 minutes to get up to sea speed, and "I need 15 minutes to come to maneuvering speed [from about 14 knots] though in an emergency I can do it faster," Johnson says.

And don't expect the merchant ship to suddenly stop if your fishing boat is in the way. Putting a merchant ship into reverse at 11 knots has no effect. "It would go miles before stopping," Johnson says. "You've got to get up to six to eight knots to start astern, and once the engine goes astern you lose all control over the ship."

All of this is another way to point out why, "The fishing boat has to see and contact the ship rather than the other way around," Johnson says. "It's the more likely to succeed method." **NF**

Michael Crowley is the Boats & Gear editor for National Fisherman.

Appendix V – Pilot Program to Help Producers Adopt Fuel-saving Trawl Gear

Gulf of Mexico Shrimp Fishery Improvement Roundtable

Increasing Fuel Efficiency Through the Use of Cambered Steel Trawl Doors and Nets

Replacing traditional wood trawl doors and nylon nets with steel cambered doors and lighter sapphire nets on shrimp trawl vessels can reduce fuel consumption by up to 39 percent. Shrimp boats using these new doors and nets decrease drag and in turn produce fewer RPMs to reach desired towing speed. In economic terms, total fuel savings are significant, with the average vessel saving 6,000 gallons of diesel, or $28,000 in fuel on an annual basis. With this level of fuel saving potential, the new doors and nets pay for themselves before the first full fishing year; over the 5-year life of the gears the net benefit to vessel owner is $104,000.

Fuel-efficient steel cambered doors

Texas A&M researchers have found that because steel cambered trawl doors improve engine efficiency, oil changes and major overhauls are not needed as frequently. Furthermore, the carbon footprint of the shrimp industry can be reduced through more fuel efficient gear.

Cost of Gear:

Steel doors: $7,000
Dummy doors/sleds: $800 x 2=$1,600
Nets: $1,500 avg. per net x 4 = $6,000
BRDs: $400 avg, x 4=$1,600
Fuel flow meter: $1,500
Total Gear Conversion Costs per Boat = $17,700
Cost Covered by Shrimp Fishery Improvement Roundtable = $8,850
Balance = $8,850

The Roundtable will also will also provide an experienced Captain to assist with installation of the gear, and training on how to use the nets and doors effectively. A Captain will be provided for up to 5 days, although it may not take that long. In addition, we will provide **$500 a day (up to 5 days)** during the training to offset the costs of boat operation during training.

Contacts:

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Appendix VI – Texas Parks and Wildlife Promotional Bulletin about the Cambered Doors

New gear will save you fuel and money.

Investing in **new gear** can **reduce fuel consumption** up to 15,000 gallons a year.

A switch to **steel cambered trawl doors** and **sapphire nets** could mean:

- Average fuel savings of 20% a year
- Longer lasting doors and nets
- Less wear on engines
- Lower maintenance costs

Better performing **bycatch reduction devices (BRDs)** could mean:

- Lower bycatch, less discarding
- Fewer crushed shrimp
- Faster sorting
- Expanded markets for sustainable product

Don't forget: As of May 2009, new rules may require your BRDs be replaced or modified for vessels fishing federal waters.

To learn more:
Contact Tonya Wiley (281-534-0131), Art Morris (361-825-3356)
at Texas Parks and Wildlife or Gary Graham (979-345-6131) at Texas Sea Grant

DỤNG CỤ MỚI SẼ ĐỂ DÀNH ĐƯỢC NHIÊN LIỆU VÀ TIỀN CHO BẠN.

Đầu tư vào dụng cụ mới có thể giảm đi nhiên liệu xài đến 15 ngàn ga lông cho mỗi năm.

Một thay đổi để xài **đôi đo sắt cong** (trái trứng) và **lưới tôm loại sắp-phai** có nghiã là:

- Để dành trung bình 20% nhiên liệu cho mỗi năm
- Lưới và đo sẽ xài được bền hơn
- Ít hao mòn máy
- Tiền bảo trì thấp

Lọc cá làm việc tốt hơn có nghiã là:

- Bắt cá ít hơn - Vứt bỏ ít hơn
- Tôm ít bị đè bẹp hơn
- Lựa tôm nhanh hơn
- Thị trường mở rộng cho sản phẩm bền lâu hơn

Xin đừng có quên: Bắt đầu từ tháng 5, 2009 luật mới có thể bắt bạn phải thay lọc cá hoặc sửa đổi lọc cá nếu bạn đánh tôm trên vùng nước của chính phủ Liên Bang.

Muốn biết thêm:
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