Development and Performance of a Sail-assisted Fishing Boat

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The modern era of fisheries development has been marked by an increasing awareness of energy efficiency. As petrochemical prices have continued to rise, energy efficiency has become nearly a developmental equivalent for economic efficiency. At the same time, population pressures have increased the demand for marine protein so that harvest of underutilized resources has become an increasing priority. In developing nations, the quandary between need for protein and deficit balance of payments created by petrochemical imports has plagued all concerned.

One solution to these problems involves the reintroduction of sail as an auxiliary power source. We say auxiliary here because sail alone tends to limit access to the resource, both temporally and geographically. As an auxiliary, sail simply enhances profitability of existing fishing operations. Although there has been much discussion of the sail-assist concept, much of it has centered on the reuse of historical hull forms and sail plans. Other applications of sail assist have concentrated on larger vessel sizes or specialized fisheries. The results of these efforts are not generally available.

I would like to present a discussion of one sail-assist project as applied in a working fleet based in Florida. This is particularly appropriate since the vessel was designed with a Caribbean application in mind, and a year ago arrived in a gale of wind at last year's GCFI meeting in Nassau. Since that time, four of the Aquarias have been built and fished in the southeastern United States as part of a longline fishing fleet.

The operation of these boats provides some comparative insights into the real value of sail assist. Since these operations occurred within a diverse profit-oriented private sector fleet with common management, between fisheries and between vessel types, comparisons are perhaps more valid than when taken from the literature.

Some background on the history of the project may be of interest in order to bring out the degree of collaboration between state-of-the-art sail and fishing technologies that have been employed. The genesis of the project came as a result of information and experience gained from the U.S. Virgin Islands Saltonstall Kennedy funded fisheries project and experience from throughout the Caribbean, which indicated that, although many of the more developed areas were converting from sail and sail assist to pure engine-powered fishing boats, this conversion was not being successful. The reasons for lack of success were various and included: (1) Small outboard powered boats, which extend the range of fishing activities, having proven unreliable and expensive to operate; (2) Larger inboard powered vessels were expensive to purchase and operate; (3) Expansion of fishing activities resulted in resource over exploitation which made the vessel uneconomical; (4) Increased fuel utilization created economic problems within the country in terms of hard currency necessary for petrochemical imports.

The Aquaria boats were developed to address some of these problems. The boat itself was largely the result of the stimulus and initiative of Tom Worrell, who assembled a design/application team consisting of the authors and Rob Ladd (Naval Architect). The boat which was developed was a product of a naval architect with a history of successful yacht designs, a builder of commercial fishing vessels, a fleet operator/seafood company and a fishery biologist with experience in development requirements of small scale and underdeveloped fisheries.

The design team considered that increased efficiency could be obtained in a variety of areas, and the end product should be a vessel that could be easily operated in lesser developed areas but would still have sufficient catching power and trip capacity to be profitably operated within our own fleet. The areas which we concentrated on for design purposes are discussed below.

<u>Speed and Power Reduction</u>.--Our other fleet activities indicated that we needed to have a 200-mile radius of operations in order to consistently find fish. An 8-knot hull speed allowed us to have this range. The resistance curve (Fig. 1) indicates that greater speeds would increase power requirements significantly. In order to provide the sail assist with enough carrying capacity to cover this range, a 6000-lb fish hold was included in the design requirement.

<u>Improved Propulsion and Auxiliary Power</u>.--The boat was designed to minimize power requirements. The sail-assist aspect further reduced these requirements. Although the vessel is designed for motor sailing, it is fully capable of operating at hull speed under either power source.

<u>Improved Fish Targeting</u>.--We wanted the sail assist to be competitive in catching power with our larger vessels. Consequently, we incorporated many of the fishing equipment and electronic fish finding options that had proven valuable on our 60- and 90-foot vessels wherever possible.

The refrigeration aspect of the design problem has yet to be completed. In many areas, ice is either unavailable or too expensive to use in quantity on extended trips. Originally, a salt water ice machine was intended for inclusion, but our unsatisfactory experience with these machines on larger boats led us to seek another avenue. Currently, a prototype chilled salt water system is under construction and should be tested soon.

The management fleet consists of 17 vessels including four 38-foot sail assists, eleven 60-foot trawlers and two 90-foot trawler/processors. We built all of the boats and operate a management facility in Port Canaveral, Florida. The fleet operates in a variety of fisheries including: (1) Calico and Icelandic scallops - one 90-foot catcher/processor; (2) Squid and groundfish - one 90-foot catcher/processor and one 60-foot

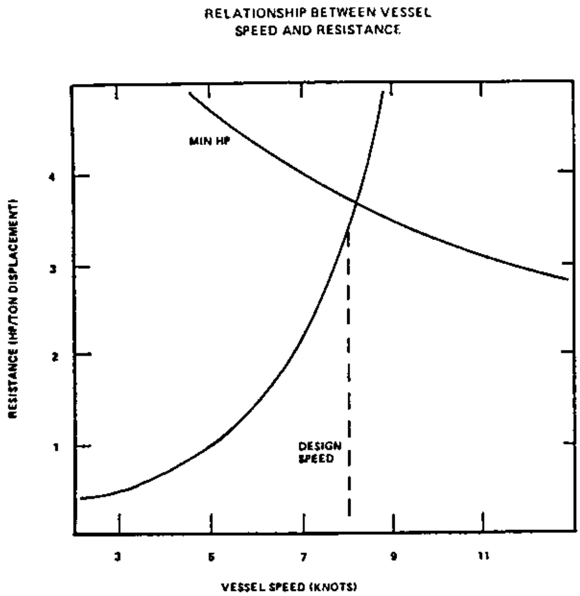

Figure 1. Speed and power requirements for the Aquaria sail assist fishing boat.

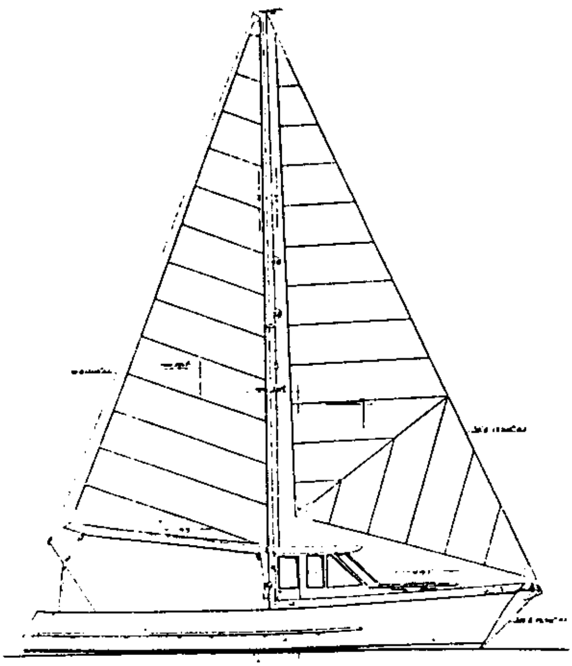

Figure 2. Aquarian sail assist line drawing.

trawler; (3) Swordfish longline - four 60-foot multipurpose trawlers; (4) Bottom longline - eight 60-foot multipurpose trawlers and four 38-foot sail assist, and (5) Shrimp trawling - two 60-foot trawlers.

The fleet operates in the Gulf of Mexico and the eastern United States. One short exploratory trip was made to Jamaica in conjunction with Antillean Pride, a Jamaican canning company. Two shrimp trawlers fish in Guyana. One 38 footer was leased to the government of the Virgin Islands as a fishery research vessel.

The design incorporates a shallow canoe-body with a high center (Fig. 2) of buoyancy and a low center of gravity to insure a most stable hull form. By using modern hydrodynamics, and an approach using beam as a dimension towards cargo carrying capability, and an aid towards stability, we were able to exceed our original goals.

The underbody configuration of the hull incorporates a low aspect ratio fin keel with a separate skeg hung rudder. The exposed shaft is supported by a "V" strut with the propeller in a clear unobstructed area for greater efficiency. Boat speed and performance are greater than anticipated by our computer analysis. We have operated our four prototype vessels in a wide range of wind and sea conditions and on all points of sail, and have found the sailing performance to be what we expected in the moderate range, and greater in the light air range. With no cargo on board, the very buoyant hull form gives a slightly corky ride, which is to be expected, but as load increases, stability, which is already very good, improves and the vessel becomes more seakindly.

The operators of these boats, although they lack sailing experience, have found the boat to be easily sailed by one person, and to be well balanced in all wind and sea conditions so that steering is easily on all points of sail. It is especially important that sailing performance be good in the light to moderate wind range since a large portion of the world's fishing resources is located in these areas.

Fishing performance has been the most encouraging aspect of the project. Initial trials with Aquaria I included: (1) Bottom longline (motor sailing) with 6-mile sets and up to 3500 hooks/day. (2) Trolling under sail and motor sailing with six lines. We have begun to set up for northwest Pacific trolling with 15 or more lines. (3) Shrimp trawling - we have successfully pulled a single 56-foot shrimp net and doors. At 20-30 plus knots wind, the net was pulled at 2.5 knots under sail alone. (4) Surface longline, trap hauling, vertical set lines and gill netting have not been tried although the boat has both the deck space and maneuverability to accommodate these fisheries.

The most convincing result comes from a comparison of the sail assists to our conventional 60-foot trawler in the bottom longline fishery. In terms of daily revenue, the sail assist produces nearly 70% as much as the larger boat despite the fact that the 60 footers set twice as many hooks. The reason for this is that the smaller boat sets lighter gear which is more effective. This also shows up in the bait expenses, as the sail assist bait costs only amount to 8.2% of the revenue, compared to 14.6% for the sixties (Table 2).

Basic operating expense (bait, fuel, ice, food and fishing supplies) only amounted to 25% of the Aquaria's revenue as contrasted to 48% for the larger trawlers (Table 1). Maintenance on the larger boats was 13.2% of the gross revenue and only 7.4% for the Aquarias. The resulting daily margin (for crew and owner) was larger for the Aquarias ($637/day) than for the larger trawlers ($523/day). Additionally, because it requires fewer crew and has lower expenses, the Aquaria has greater potential for net profit.

Table 1. Comparison of expenses (given as % of total revenue) between a sixty foot long liner (motor vessel) and a thirty eight foot sail assisted long liner. Total expenses include bait, fuel, food and fishing supplies

Area	Potential Savings (%)
Speed and power reduction	20
Improved propulsion systems	20
Improved Auxillary Power systems	3
Improved hull design	3
Improved fishing gear	25
Selection of fishing methods	20
Alternative Energy Sources	30
Fish forecasting	?

Table 2. Comparison of energy conversion (kcal of fuel/Kcal of product) for selected fisheries

Fishery		Kcal Input/ Kcal Product
North east ground fish trawler		4.1
Florida Spanish mackerel Gillivet		7.8
Sail assisted bottom longliner	(38ft)	7.9
Squid trawler/processor	(90ft)	15.3
Virgin Islands trap fishery	(22ft)	18.5
Bottom longliner	(60ft)	20.3
Scallop dragger/processor	(90ft)	39.5
Swordfish longliner	(60ft)	49.8
Shrimp trawler Guyana	(60ft)	191.7
F/A Gulf shrimp trawler		198.0

As mentioned in the introduction, fuel efficiency was an aspect emphasized in the design project. Fuel costs were only 5% of revenue with the sail assist as compared to 12% with the sixty's. When conversion fuel to product is analyzed, the sail assists are over 2.5 times as efficient as our fleet of sixty's. When compared to other fisheries, both our own boats and other figures from the literature, the sail assists provides one of the most fuel efficient operations available. Table 1 also indicates that fuel efficiency does not equate economic efficiency. Production of high priced products like shrimp, swordfish and scallops may provide revenue greatly in excess of the increased fuel involved in their production.

SUMMARY

Our experience in the application of sail assist from the drawing board to the very real world of operation of commercial fishing boats has been extremely encouraging. The sail-assist Aquaria vessels have proven to be energy efficient as might be expected. Additionally, the choice of vessel size and other design aspects has produced a powerful fishing machine equivalent to much larger and more expensive vessels.