Trials and Tribulations of a Yacht Builder: The Design, Construction and Testing of the Sportfishing Yacht "Marlena"

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ABSTRACT

In November of 1998 Trinity Yachts, Inc., a division of Halter Marine Group, delivered its fourth vessel, the sportfishing yacht "Marlena". At the time of delivery it was the largest sportfishing yacht in the world with an overall length of 133'-8" and a full load displacement of 180 lt. The vessel is powered with Paxman engines with a total of 7000 bhp and achieved over 30 knots on trials in a half load condition. The vessel was constructed entirely of aluminum and was classed by ABS. This paper will explore the various compromises made during the design and construction of the vessel and will present results of trials and testing.

INTRODUCTION

The plan to design and build the sportfishing yacht "Marlena" was conceived during the summer of 1996. The owner, Sam Gershowitz, and his wife Marlena then owned a 93' sportfish built by Lydia and completed by the owner. Their goal was to expand on this experience to create a larger vessel suitable for their growing family while maintaining the functional aspects required of any sportfishing vessel.

During that summer and fall they worked with designer Doug Sharp and Trinity Yachts to develop a concept design to meet this vision. With all vessels, design is an iterative process that seeks to integrate numerous and often conflicting sets of requirements. This vessel was no exception. Ultimately, however, it was the responsibility of Trinity Yachts to translate the owner's and designer's vision into a successful reality.

The owner set ambitious goals for performance. It was desired that the vessel achieve a half load speed in the low to mid 30's while maintaining a draft not greater than 6'. In addition, the vessel would be US flag, under 200 gross tons and classed by ABS. In the end, a contract was signed guarantying the owner 34 knots and a draft of

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6'-2" at an agreed upon half load condition, with adjustments to be made for any change orders impacting the weight.

By November of 1996, Trinity Yachts was halfway through construction of their first vessel, a 150' tri-level motor yacht, and had two additional vessels under construction. The contract to build the sportfishing yacht was welcomed as a challenge and an opportunity to expand the company's portfolio.

VESSEL DESCRIPTION

The overall styling and proportions of the vessel are fairly conventional when compared with smaller sportfishing vessels. The true size of the vessel is often not apparent until viewed up close and first hand. Figures 1 and 2 show the exterior profile and general arrangements and Table 1 summarizes the principal characteristics.

Table 1- Principal Characteristics

Length O.A. (extreme)	133'-8"
Length O.A. (mld.)	126'-0"
Length W.L.	112'-11"
Beam (mld.)	26'-0"
Depth – interior main deck	13'-2"
Draft – design WL	6'-0"
Displacement – half load	156 lt
FO capacity	10,000 gal
FW capacity	1740 gal
Owner's Party	10
Crew	4

The vessel is arranged with a master stateroom and four guest staterooms below the main deck forward. Each of the staterooms has a private toilet and shower, and the master has both his and hers heads sharing a large common shower. The location of the heads aft of the master stateroom also provides a sound barrier, thereby reducing noise from the engine room in the owner's stateroom. A utility space is provided off the foyer to allow for ease of housekeeping and provide additional storage space. Access to tanks and voids containing auxiliary machinery is provided beneath beds and in closet floors where practical. Natural light is provided in each space through portlights or skylights.

The engine room is located aft of amidships and contains the main engines, generators, switchboard, A/C chiller unit and the majority of auxiliary systems. A pair of saddle tanks are provided at the forward end of the engine room which function as fuel oil day tanks. In addition, two centerline fuel tanks are provided below the guest accommodations between frames 15 and 25. A pair of fresh water tanks is located below the forward guest staterooms between frames 10-13. The tank arrangement allows sufficient flexibility to adjust trim by transferring fuel or filling the fresh water tanks with the onboard watermaker. Independent sewage and grey water tanks are located in the engine room and below the guest accommodations as required.

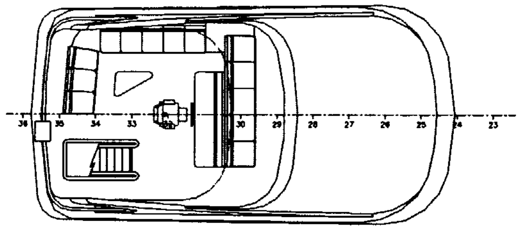
The crew's quarters are located aft of the engine room and are accessed through a companionway from the cockpit deck. The crew's quarters are rather Spartan for a vessel of this size and the captain usually occupies one of the guest staterooms unless a full complement of guests are onboard.

The main salon and dining room are open and are separated visually by the engine room intake trunks and cabinetry in way of the dining room. A noticeable design element is the floating staircase above the television going up to the sky lounge. The intake louvers for the engine room are located in the house sides in the paint stripe. Exhausts are provided port and starboard in the aft corners of the main salon below cabinet level.

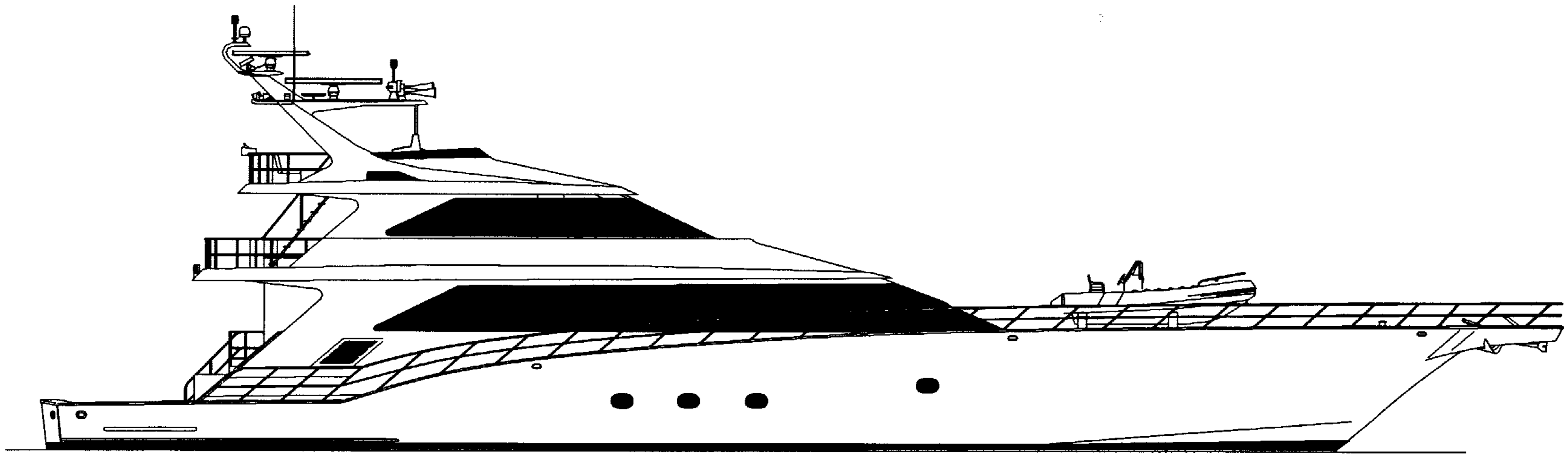
The galley is located forward on the port side of the main deck, with the stairs leading down to the guest accommodations on the starboard side. The galley is arranged with a center island and a settee for crew and guests. The galley is open to the dining room per the owner's request, as he often cooks his own meals when onboard.

The cockpit and aft deck are the business end of the boat and the owner was closely involved in all details of their arrangement. The aft main deck is furnished with a settee close to the action in the cockpit, and a day head is available for use while fishing. Large bait freezers are located port and starboard in cabinets at the forward end of the cockpit. Refrigerated fish boxes 3' wide and 7' long with hydraulically actuated hatches are provided below the cockpit port and starboard. A live well is located on centerline at the transom with a plate glass face on the forward side. Rod stowage is provided in three locations: below the bulwarks outboard, below the stairs to the pilothouse deck and in the passageway in the crew quarters. Two 3500 lb. capstans are located on raised platforms below the bulwarks in the stern corners and shore power receptacles are provided port and starboard of the live well. Steps up to the side decks are provided in the forward corners and a control station is located in the forward cabinets on the starboard side.

The side decks lead forward to the expansive foredeck. Partial bulwarks 15" high are capped by an aluminum rub rail. Painted aluminum handrails run from the bow all the way aft to the cockpit. Two sets of hawse eyes with horns are located port and starboard in the bulwarks for mooring. A 5000 lb. hydraulic davit is provided to launch the 18' tender. Deck storage is provided port and starboard of a seating area recessed in the forward superstructure.



FLYBRIDGE DECK



OUTBOARD PROFILE

Figure 1: Outboard Profile and Flybridge Deck

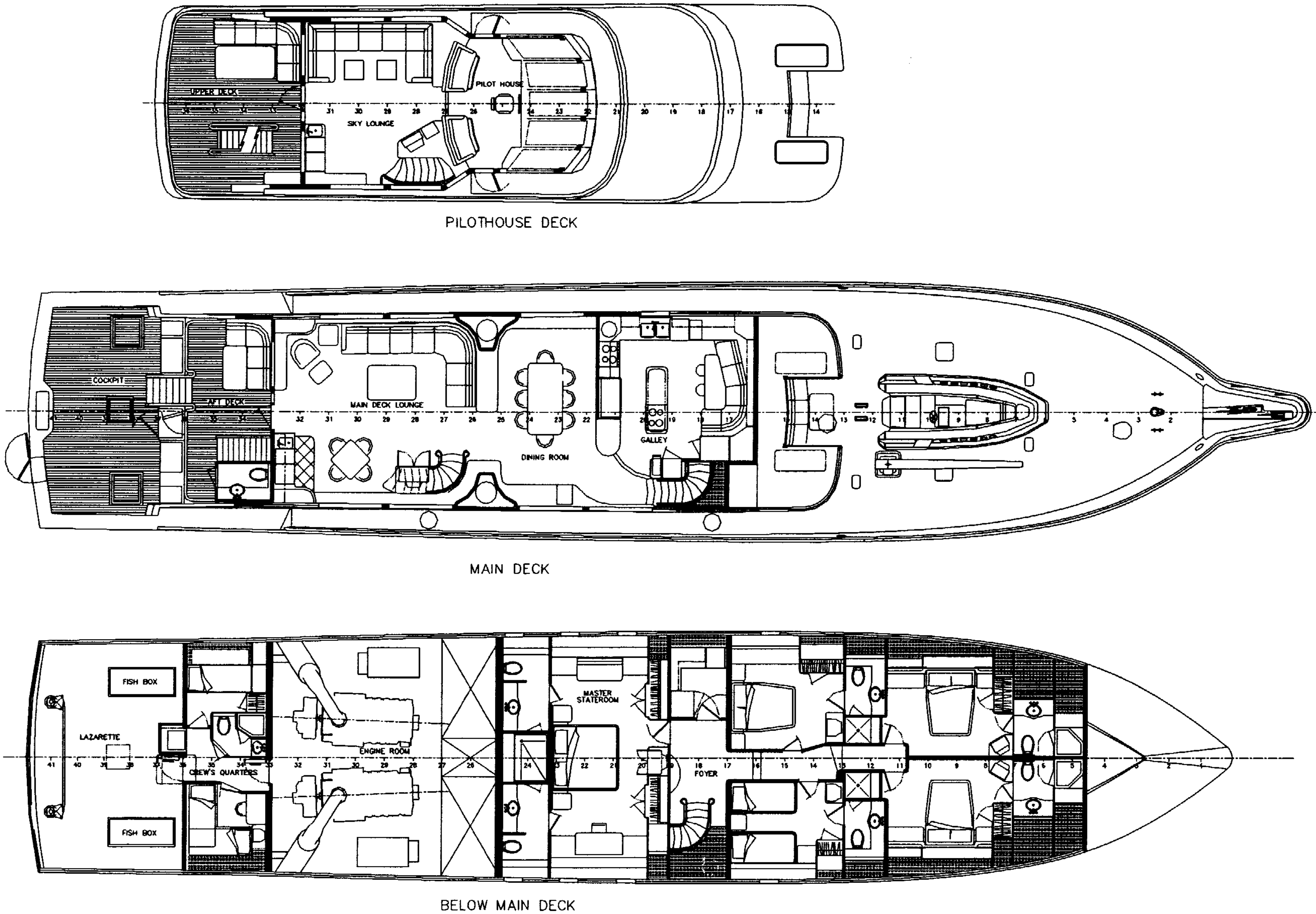


Figure 2: General Arrangements

The twin anchors are located on a bow pulpit which extends out 8' forward of the bow. The vessel is provided with a Fortress FX-125 anchor with 2000' of rope, and a 242 lb. Bruce anchor with 450' of 5/8" chain for more serious conditions. The anchors are handled with a single 6000 lb. vertical windlass. A chain locker furred with wood planking to eliminate corrosion from dissimilar metals is provided in the forepeak.

On the pilothouse deck, the sky lounge is open to the pilothouse and the two are separated by a pair of raised riding seats. The riding seats provide good visibility and space for chart storage below. The sky lounge provides additional entertaining space and the large sofa also hides a fold-out queen size sleeper bed. The walk around forward of the pilothouse provides access to the wing stations and for cleaning and maintenance. The wing stations were located facing aft since this is the traditional direction for docking sportfishing boats. The aft deck has a large table and settee which provides an optional location for outside dining. Floating stairs lead from the aft deck to the flybridge.

The flybridge deck contains two steering stations: the main station facing forward, and a smaller one facing aft with an excellent view of the cockpit. A tuna tower is not required since the flybridge deck itself is 22'-9" above the water. As such, a hard top was designed to provide additional shade and a platform for the large array of electronics. A smaller upper mast is also provided for additional electronics. Seating is provided below the hardtop and forward of the main steering station.

HULL FORM

The vessel was designed as a fairly conventional single chine planing hull. A body plan of the vessel is provided as Figure 3 and the characteristics of the hull are listed in Table 2. The bottom sections aft are straight with a slight warp as deadrise decreases towards the stern. Deadrise at the transom is 8 degrees and does not appear to cause undue rolling when trolling at slow speeds. The bottom sections forward are slightly convex for several reasons; this allows for easier plating, provides additional stiffness and improves seakeeping. The deadrise at station 3 is 25 degrees. As a rule of thumb this is considered a minimum based on the builder's experience. A deadrise of closer to 30 degrees would have been preferred, but was not feasible due to the arrangement of the forward guest staterooms, and the location of the forward guest beds in particular.

A single hard chine runs the entire length of the vessel with a width of 9" from station 3 aft. The chine detail provides a sharp edge for clean separation away from the bottom and serves as an effective spray rail forward.

The bottom plating aft was allowed to extend several inches past the transom. This provides a cover over the rudders and reduces the possibility of drawing air down to the trailing edge and ventilating the rudders. It also provides a sharp edge for clean separation and has the effect of lengthening the bottom surface of the boat.

The hull sides forward have concave sections with a moderate amount of flare which gradually transition

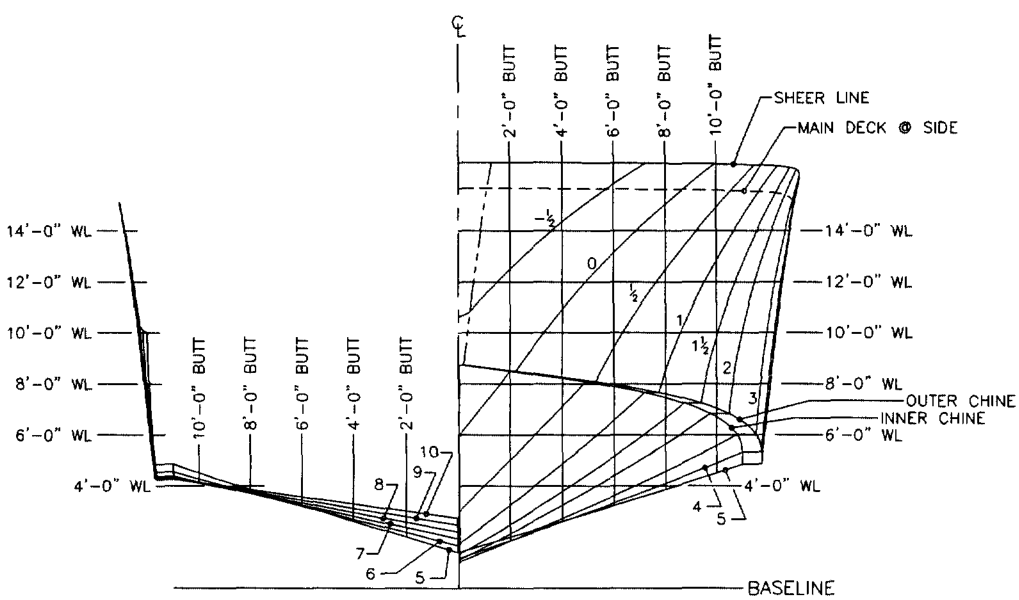


Figure 3: Body Plan

Table 2 – Hull Characteristics at the 6'-0" DWL

Displacement	167.4 lt
LCB aft of sta. 0	62.89 ft
LCF aft of sta. 0	63.32 ft
TPI	5.49 lt/in
MT1"	41.60 ft-lb./in
KMt	21.00 ft
Cb	.438
Cp	.784
Cx	.642
Cwp	.857
Length/volume ratio	6.26
Displ./length ratio	116.8
Wetted surface	2704 sq. ft.

to slightly convex sections at the transom. For aesthetic reasons some additional flare would have been preferred amidships, however, the arrangement of the owner's stateroom required fairly full sections.

Tunnels and Propellers

In the past the builder has had success with cylindrical tunnel sections with an "S" shaped ramp at the forward end, as shown in Figure 4A. For this application, however, a fully molded tunnel without any knuckles was desired. Also, the builder has witnessed some minor problems with welds cracking on frames at sharp tunnel intersections with the hull. It has been suggested that this may be due to exciting forces caused by pressure differences as the propeller blades pass by these intersections.

As a result, the tunnels were designed as shown in Figure 4B. The radius at the top of the tunnel was held constant while the intersection lines with the hull were moved away from the tunnel centerline. The sections between the tangents and the intersections with the hull are straight. It was intended that this would provide a relatively clean flow of water to the propellers while moving potential stress points further away from exciting forces. It also has the effect of increasing the angle at the tunnel/hull intersection.

It was desired that the tunnel depth be minimized to reduce losses in efficiency, minimize the possibility of ventilating the rudders and allow sufficient space beneath the cockpit for steering gear. However, the strict draft restriction and propeller design eventually drove the depth of the tunnels. In the end a tip clearance of only 13.5% was chosen; this allowed the tops of the tunnels to be 12" below the design waterline. This appears to have been sufficient as no excessive vibration was noticed during trials.

The propellers were designed and manufactured by Brunton's. They were selected after discussions with several manufacturers based on price and their experience with several patrol boat applications of similar size, and with similar speed and power requirements. The propellers were custom designed with a high blade area ratio and moderate skew and rake. The characteristics of the propellers are listed in Table 3. The propellers were designed for a gear ratio of 2.55:1. This was determined to provide the minimum diameter possible without excess risk of cavitation. The propellers turn outboard at the top in the ahead condition.

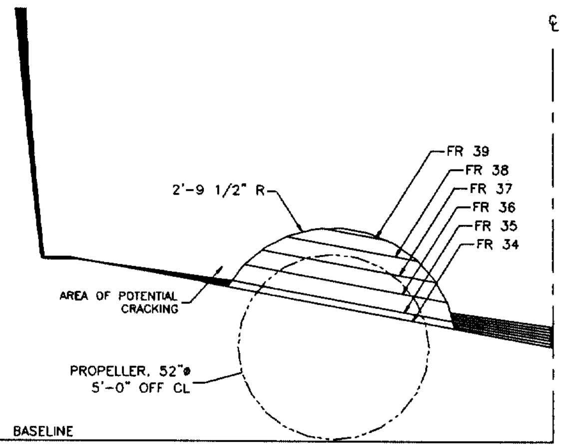


Figure 4A: Previous Tunnel Design

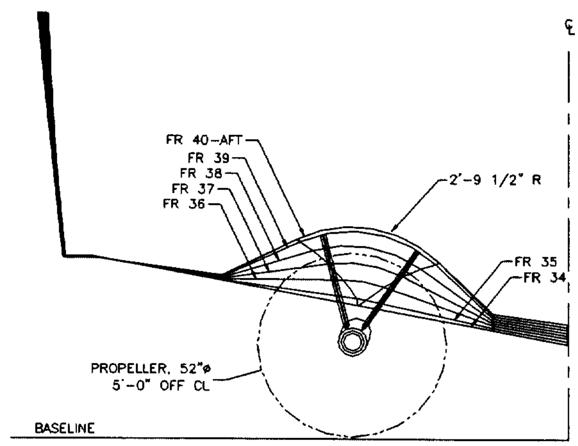


Figure 4B: Final Tunnel Design

Table 3 – Propeller Characteristics

No. Blades	5
Diameter	52.0"
Mean Pitch	65.3"
B.A.R.	1.00
Skew	9.45"
Rake	1.97"
Material	NiBrAl
Weight	805 lb.

APPENDAGES

Struts

The vessel was fitted with aluminum V-struts as shown in Figures 4B and 5. For high performance vessels it is the builder's preference to use single stainless steel struts bolted in and chocked in place. However, this method was rejected by the owner's representative, possibly because of a bad experience with an aluminum single strut application. The struts were welded directly to an insert plate in the top of the tunnel and are backed up by longitudinal girders directly above.

The struts are fabricated from 1 ¼" aluminum plate faired at both the leading and trailing edges. The struts were sized in accordance with the method outlined in Ship Design and Construction (Taggart, 1980) as an alternate compliance to the ABS Rules. This method results in more reasonable scantlings and has been used by the builder on a wide variety of vessel types for many years without incident. It provides a required section modulus and moment of inertia equivalent to a NACA section and compares well to scantlings required by Lloydes and DNV. Unfortunately, ABS has indicated that they will no longer accept this method as an alternate compliance.

Rudders and Steering Gear

The rudders are of the semi-balanced type with foil shaped sections and a fairing above as shown in Figure 5. The rudders are constructed of 316 stainless steel with 5" Aquamet 17 stocks. The stocks are tapered below the lower shaft bearing to reduce weight and allow for finer sections lower on the rudder. The top of the trailing edge is cut away to reduce the possibility of ventilating the rudders. The rudders are offset from the propeller centerline to allow the shafts to be pulled without first dropping the rudders. The rudder stock is aligned with the outboard strut leg to allow continuity of the longitudinal girder which supports both appendages. The rudders were toed in about 2 degrees at the leading edge to prevent chattering.

The steering gear was designed to allow the rudders to travel 30 degrees to either side. This is less than the 35 degrees which is normally required by ABS. In this case the argument was made that the rudders would normally stall above about 25 degrees in the free running condition, and that the twin screw configuration with a bow thruster provides adequate maneuverability when operating at slow speeds. It is interesting that ABS has a specific requirement for rudder travel but does not have a rule for rudder size. Each of the rudders on this vessel has an area of 6.95 sq.ft., for a total of roughly 2% of the lateral underwater area.

Stabilizers

The vessel was provided with a pair of 16 sq.ft. Naiad stabilizer fins and a digital roll control system. The fins remain active throughout the entire speed range, however, above 25 knots the range of motion is reduced. The fins were optimized for a speed of about 18 knots which is a normal cruising speed during transits. At this speed the fins were predicted to reduce roll by up to 90%. For slow speed trolling the fins are less effective and may reduce roll by only 50%. It may be noted that 12 sq.ft fins were originally specified and these were later increased in size to enhance performance at slower speed.

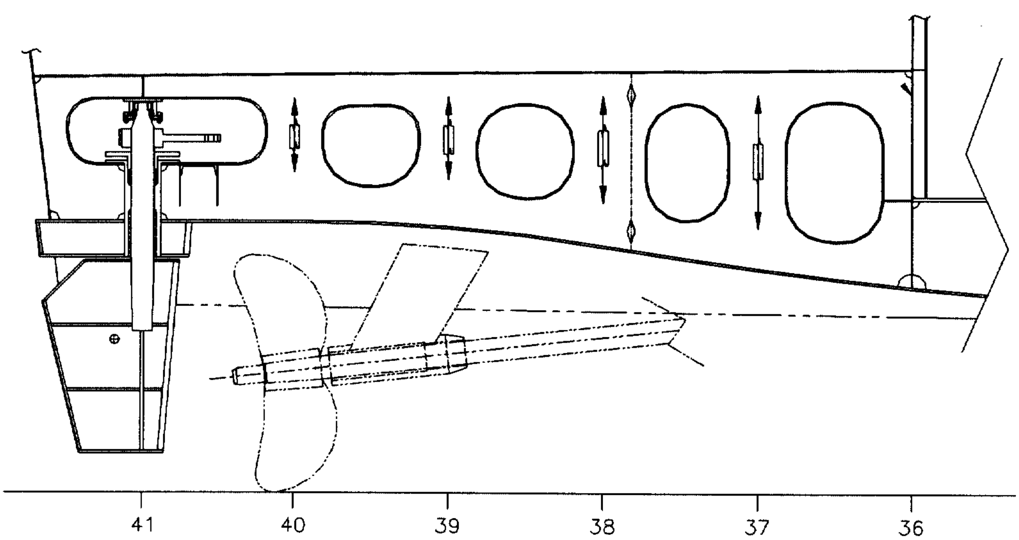


Figure 5: Running Gear

The fins are located below steps outboard in the closets of the master stateroom. This position, which is about 42% of the waterline length aft of the forward perpendicular, was recommended by the manufacturer. In general, they recommend the fins be located plus or minus 10% from amidships and prefer to see the fins forward of amidships for higher speed applications. There was some concern that the fins might experience some slamming loads this far forward but none have been observed. Another concern was that drag might be increased if true buttock flow was not yet achieved. However, manual adjustment of the fins while running showed no noticeable change in speed up to an angle of attack of 10 degrees.

On future designs, consideration should be given to active trim tabs to provide roll stabilization. This would result in reduced drag and minimize the potential for damage. Unfortunately, this system was not available from Naiad early enough to be included on this vessel.

Bow Thruster

The vessel was provided with an American 60 hp electric Duoprop bow thruster. The thruster was located at frame 5, as far forward as possible while maintaining an adequate depth to prevent drawing air into the thruster and sufficient breadth to install the unit. A fairing was provided aft of the opening and a flat bar grating was installed as a trash guard with the bars perpendicular to the flow across the opening. On subsequent vessels the builder has eliminated the fairing, which is generally quite shallow on vessels of this type, and instead, relies on the grating to allow water to cascade over the opening. It is believed that the fairing does not significantly reduce resistance for these vessels while it does increase production costs. It may also be noted that the thruster is often above the waterline for this vessel while in the planing mode.

Skeg

The vessel is fitted with a double plated skeg that extends from the forefoot aft to about frame 35. The bottom of the skeg is fabricated from ½" plate and the skeg was designed with keel drag so that it would ground before either the propellers or rudders. The result is a fairly large skeg which adds to the wetted surface and contributes significantly to the directional stability of the vessel.

Trim Wedges

While not a part of the original design, a pair of wedges serving as trim tabs were added to the vessel inboard and outboard of the propeller tunnels following preliminary sea trials. The wedges extended 18" forward from the transom with an angle of attack of 3.2 degrees and were faired in at the forward edge using a hard epoxy compound. This had the effect of reducing trim at full speed from about 4 degrees down to about 2.5 degrees.

STRUCTURE

The vessel structure was fabricated entirely of welded aluminum construction. The hull is longitudinally framed with transverse webs on approximately 3' centers. The bottom is generally 5/16" plate which is increased to ½" aft. The sides and main deck are ¼" plate, however, the interior main deck was reduced to 3/16". A typical frame section is shown as Figure 6.

In order to save weight the scantlings were minimized to meet the ABS Rules. Longitudinal stiffeners were spaced to maintain the plating sizes listed above. The transverse webs and longitudinal girders were fabricated from built-up sections. This increases production hours, but allowed the builder to optimize for weight savings. In addition, lightening holes and scallops were added wherever possible to reduce weight.

In order to stay below 200 gross tons the vessel was deep framed below the guest accommodations with every other frame being a deep member. The cockpit deck was taken as the tonnage deck and all bottom and side longitudinals run below this deck were made intercostal.

The double bottom tanks are arranged with the margin plates perpendicular to the shell plate for additional rigidity. The stiffeners for the tank tops are located on top of the tanks and are used to support the flooring for the interior. This gap eliminates the possibility of sweating on top of the floors and allows manholes, fittings and some piping to be located between the tank top and flooring.

Particular attention was given to the structure below the cockpit and in way of the propellers and running gear. The engine foundations were continued aft below the crew's quarters and cockpit to form four non-tight longitudinal bulkheads. These were aligned directly above the struts and rudder posts as noted above.

The superstructure and arch were designed to be lightweight and were constructed from 3/16" and 1/8" plate with a combination of transverse and longitudinal framing. Cantilevered beams support the aft deck overhangs. Additional support is provided by the day head bulkheads, and the aft flybridge deck is reinforced by the built-in aluminum seating on the deck above. The hard top is supported by the arch sides and by stanchions built-in to the forward console.

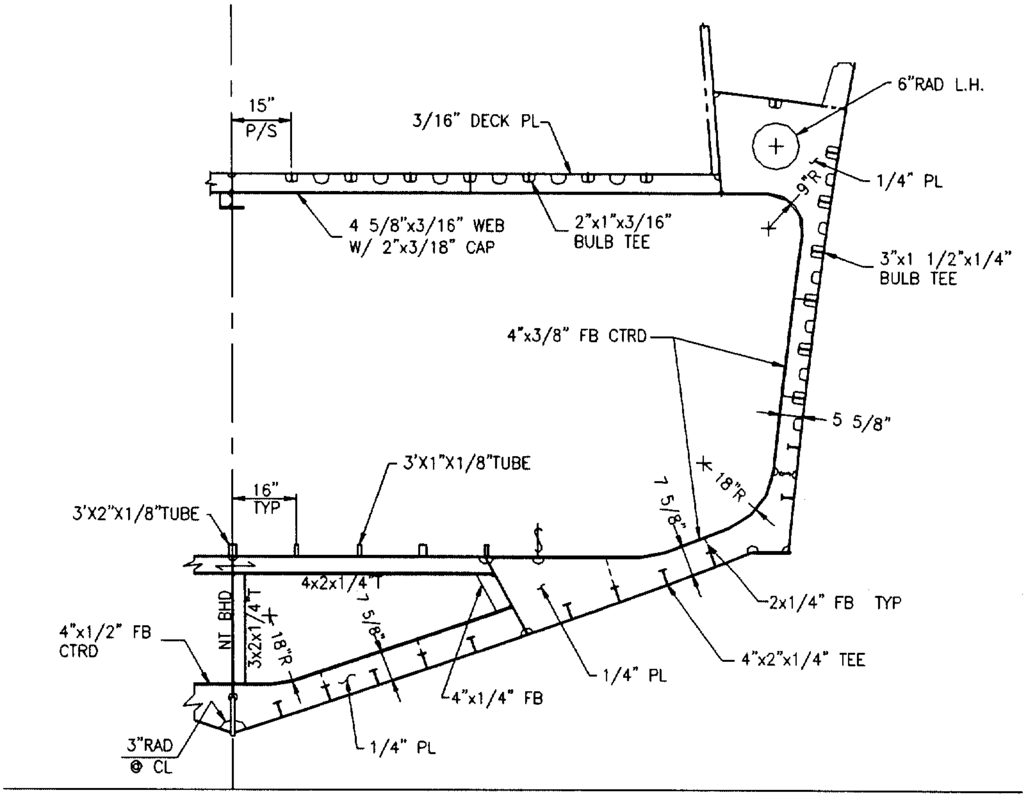


Figure 6: Typical Section

In general, the curved sections of the superstructure consist of developable or nearly developable shapes to ease plating and minimize the amount of fairing compound required. It was found that 3/16" plate worked best in these areas, while 1/8" plate was too easily pulled to less fair shapes.

Local "oil canning" was noticed on some of the 3/16" interior decks which have no camber. In an effort to reduce weight the stiffener spacing had been increased to 15". On future designs this spacing should be reduced to about 12". The oil canning was eliminated by drilling small holes in the affected areas and welding these up to "pull" the plating tight.

In general the design philosophy for structure was to optimize the overall structure to save weight, with particular emphasis on reducing plating thickness throughout, and then to be conservative in providing local stiffening in highly stressed areas.

WEIGHTS

With any high speed vessel, the ability to accurately predict and control weights throughout the construction process is essential to the success of the project, and yachts are no exception.

At the time of contract signing the lightship weight for the vessel was estimated to be 116 lt. A breakdown of the estimate is given in Table 4. Included in the above figure was an allowance of 8000 lb. for owner furnished equipment and stores. It may be noted that the initial weight estimate predicted the lightship weight to be only 89 lt.

Throughout the design and construction of the vessel weight savings was given particular emphasis. Nidacore panels were substituted for plywood subfloors and joiner bulkheads which were then the builder's standard. The weight of overhead ceiling panels was minimized by cutting lightening holes in the plywood supporting the padded panels. Where possible the use of fairing compound was minimized; in several cases the structure was even reworked to minimize distortion. Structural modules were weighed when moving and major equipment was weighed upon receipt.

In the end, however, the final lightship weight of 136 lt exceeded the initial prediction for a variety of reasons. Foremost among these was the builder's limited experience in estimating weights for yacht interiors and fairing. As noted above, the builder was midway through construction of its first vessel when this contract was signed. As such, proper feedback was not yet available on the estimating techniques used for these items. In retrospect it appears that interior and joinery grew by about 6 lt and fairing and painting by an additional 4.5 lt.

In addition, numerous changes were made by the owner during design and construction. These included extending the aft deck overhangs by about 3 ½', adding the tender and davit on the foredeck, increasing the amount of marble surfaces, increasing the size of the anchors, switching from rope to chain, and adding a chain locker in the forepeak. These changes officially added another 5.2 lt, and it is probable that additional increases went unrecorded.

The remaining difference was mainly due to errors and omissions in mechanical and outfit items, most notably the fish boxes, handrails and gear couplings. It may be noted that the builder found the actual weight of the main engines, gears and generators along with loose equipment exceeded the published values by roughly 1.7 lt. An estimate of the final lightship breakdown is also given in Table 4.

Table 4 – Breakdown of Lightship Weights

	Initial Estimate	Final Estimate
Structure	39.3	42.8
Propulsion	19.2	21.1
Mechanical	13.4	14.4
Electrical	8.4	8.6
Outfit	8.9	10.6
Joiner	17.7	25.2
Paint/Fairing	5.1	9.6
O.F.E.	3.6	3.6
Total	115.6	135.9

MACHINERY

The vessel is powered by a pair of Paxman 12-cylinder VP185 series engines rated at 3500 bhp each at 1950 rpm. The engines are 24 volt DC start, heat exchanger cooled and provided with an electronic control system. They are connected via Vulcan couplings to ZF model BW 755 gears with PTO's for the stabilizer pumps. The gear ratio is 2.55:1 and the shafts have a diameter of 5". The engines are resiliently mounted while the gears are bolted directly to the foundations.

The Paxman engines provide a fairly compact package for the given horsepower and have a relatively low weight to horsepower ratio. They are, however, relatively tall, a problem which is exacerbated by having the exhaust discharge from the top of the engine. Early in the design process this became a driving factor in determining the height of the main deck.

The vessel is provided with a pair of Northern Lights, 65 kw, 3 phase, 60 hz generators. These are enclosed in sound shields and are resiliently mounted on skids which, in turn, are resiliently mounted on foundations in the engine room. The switchboard is also located in the engine room and is configured as a split bus design for non-parallel operation. This allows one generator to supply ship's service power and the second generator to be brought on line for the bow thruster.

The vessel is equipped with an Aqua Air chilled water air conditioning system with a capacity of 20 tons. The chiller unit is located in the engine room below the workbench and individual air handling units are located throughout the accommodations.

Engine room ventilation is accomplished with a pair of supply fans mounted in trunks on the main deck above the forward engine room, and another pair of exhaust fans at the aft end of the engine room. Both intakes and exhausts are provided with vane type moisture eliminators. The fans, dampers and automated control system were provided by Delta-T. The control system automatically increases the variable speed supply fans upon sensing a pressure drop, and similarly, increases the speed of the exhaust fans to compensate for any rise in temperature. These fans were found to be lighter and smaller than typical commercial fans.

The arrangement of the main engine room was a particular challenge. The end result, shown as Figure 7, was a tight arrangement with little space left to waste. The main engines were moved as far inboard as possible and the shafts were canted outboard going aft. While crowded in some spots, this arrangement provides clear access between the engines and in front of the workbench and switchboard. Overall the feeling is not quite as "cramped" as on smaller sportfishing boats or on many patrol vessels of similar size.

Certain auxiliary equipment was located outside the main engine room. The fresh water pumps and pressure sets were located beneath the guest accommodations near the fresh water tanks. The compressors for the cockpit freezers and the ice maker for the fish boxes were located below the crew's quarters aft. The receiver for the air compressor was located below the cabin top forward of the flybridge, close to the air horn, and the CO2 bottles were located in a vented compartment below the stairs to the guest accommodations.

Exhaust

The vessel was originally specified to have a wet exhaust through the transom with a pot-style water lift muffler. Upon further review it was determined that this would mean passing an exhaust pipe roughly 20" in diameter through the crew quarters outboard and beneath the cockpit. In addition, the entire exhaust would discharge near the cockpit, a less than desirable location when fishing.

As such, it was decided that an underwater exhaust exiting through the bottom in the engine room with a bypass through the transom would be a better approach. A smaller muffler was designed with the intent of further reducing exhaust noise and providing some

EQUIPMENT LIST		
ITEM	QTY.	DESCRIPTION
1	2	MAIN ENGINE, PAXMAN, 3500 BHP @1950 RPM
2	2	GENERATOR, 65KW 208/120 3PH 60HZ 1800RPM
3	1	CHILLER UNIT, 20TON, 208VAC, 3PH
5	1	STABILIZER FLUID CONDITIONER
7	1	STABILIZER COOLING PUMP
8	1	BILGE MANIFOLD
9	2	FIRE/BILGE PUMP- 5HP 208VAC, 3HP,70GPM,@140FT.
10	1	FUEL TRANSFER MANIFOLD
11	2	FLOW METER w/ SWITCH
12	2	FUEL TRANSFER PUMP-1.5HP, 208VAC, 1800RPM, 30GPM
14	2	GENERATOR WET MUFFLER, INSIDE SOUND SHIELD
19	1	WATER MAKER-1500GPD
20	1	OIL CHANGE PUMP-.75HP,115VAC
21	2	BLOWER (INTAKE) 24" /208VAC/3PH
22	2	BLOWER (EXHAUST) 19" /208VAC/3PH
23	2	SEA WTR PUMP, CHILLER
27	1	AIR COMPRESSOR w/30GAL AIR RECEIVER-3HP, 208VAC
28	1	AIR COMPRESSOR w/3GAL AIR RECEIVER-1HP, 115VAC
29	4	MACERATOR PUMP-1HP,24VDC
32	1	MAIN SWITCH PANEL
33	2	ISOLATION TRANSFORMER-45KVA
34	2	BATTERY CHARGER-40AMP 24VDC/115VAC
35	2	BATTERY CHARGER-40AMP 12VDC/115VAC
36	12	BATTERY,HEAVY DUTY, 8D
38	2	KIM HOTSTARTS
39	2	SEA CHEST
40	2	DISCHARGE BOX
41	2	STRAINER, MAIN ENGINE, 5"
42	2	STRAINER AUX. 3"
43	1	FUEL CENTRIFUGE
44	1	PUMP, WATER MAKER, LOW PRESSURE
46	1	PUMP, FREEZER COMPRESSOR COOLING
47	1	PUMP, ICE MAKER COOLING PUMP
52	2	PUMP, MAIN ENGINE LUBE OIL PRIMING
53	2	PROPULSION LOGIC PANEL, SUPPLIED WITH ENGINES
54	2	LOCAL CONTROL PANEL, SUPPLIED WITH ENGINES

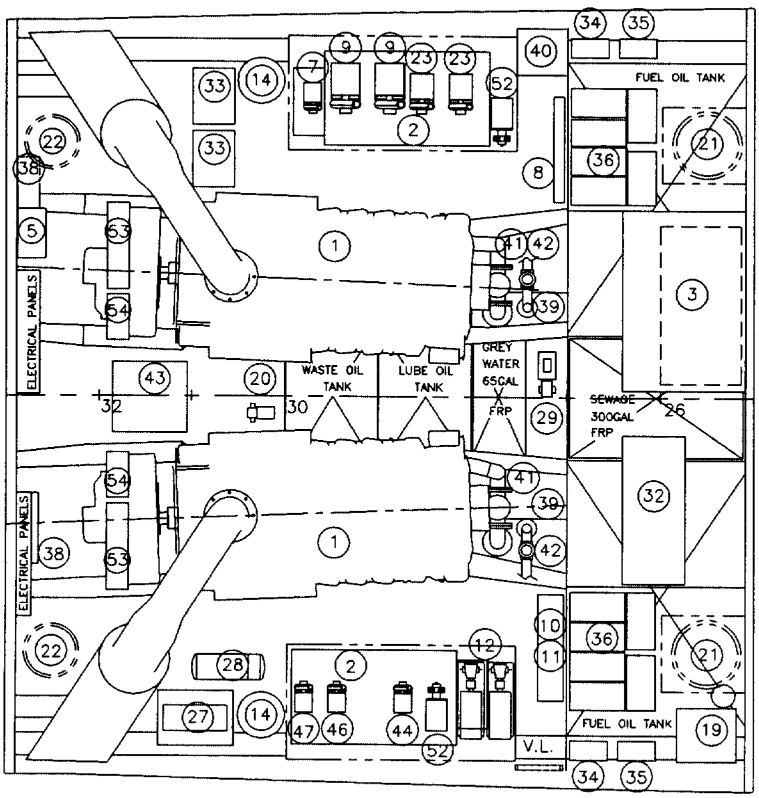


Figure 7: Machinery Arrangement

baffling to prevent flooding the exhaust when backing down.

However, this approach presented several potential problems as well. The first of these was increasing back pressure above acceptable levels for the main engines. Paxman normally recommends that back pressure on these engines not exceed 12", however, for this application they were willing to allow up to 20" without de-rating the performance. This is a relatively stringent requirement, but is not unusual for high performance engines. Secondly, there was concern that engine exhaust would migrate into the relatively wide tunnels causing ventilation of the propellers. This could lead to extreme cavitation and loss of speed.

In an effort to counter these obstacles a wedge shaped fairing was provided forward of each main exhaust. Resistance was a concern and the fairings were made only 6" deep with a 1:12 slope. In addition, a 6" deep "fence" was continued aft from the fairings along the outboard edge of the tunnels in hopes of preventing exhaust gases from entering the tunnels. The configuration described is illustrated as Figure 8.

While it was hoped that this would solve the problems, experience during preliminary trials proved otherwise. Readings taken during the initial trials showed that the wedges were not effective and back pressures were well in excess of the engine manufacturer's limits. The wedges were redesigned with a lip around the leading edge of the exhausts which was 3" deep and had a slope of 45 degrees. The intent was to create a deeper "hole" in the water for the exhaust gas to escape into. This was nearly successful in reducing the back pressure; however, the exhaust gases discharging below the hull now flowed into the tunnels causing a massive cavitation breakdown. The "fences" were modified to a depth of 18" in an extreme attempt to eliminate the problem, however, the exhaust gases still found their way into the tunnels.

Finally, after much debate it was decided to eliminate the mufflers and redirect the underwater exhausts through the sides of the hull just below the waterline. It was hoped that this solution would eliminate cavitation by locating the exhausts away from the bottom, and would reduce back pressure by decreasing the depth of the exhausts. This approach also had the effect of reducing resistance by eliminating the fairings and exhaust "fences". Potential drawbacks were noise when the exhausts would be exposed when rolling in a seaway, and sooting of the hull sides.

This approach finally proved successful. On the next set of trials the back pressures were maintained below the engine manufacturer's limits and the absence of cavitation was evident in the increased speed and lack of air visible in the wash at the transom. While there is some sooting of the hull sides, noise levels were not significantly increased on the aft decks.

TRIALS RESULTS

Speed and Power

Based on the weight growth discussed above, the builder was greatly concerned about the trials performance. Acceptance trials were conducted in the Gulf of Mexico and in the Mississippi Gulf Outlet ship channel. Conditions were clear with a breeze of about 10 knots from the north and seas of 3-4 feet in the Gulf. Speed trials were conducted in the ship channel with an average depth of 40' and calm seas. Runs were made in both directions and speed was calculated based on the time to travel one nautical mile using the vessel's GPS to measure distance. The half load trials displacement was 156 lt and the initial trim was negligible.

The results of these trials are shown in Figure 9 along with the predicted speed using the Savitsky method with a Ca of 0.0004 and margins for appendage

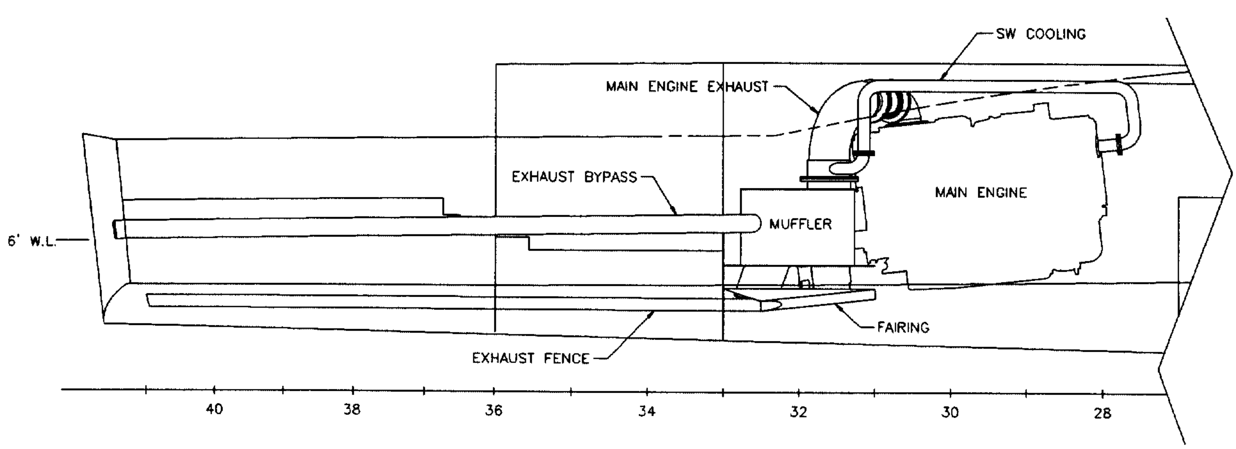


Figure 8: Original Exhaust Configuration

drag, wind resistance and a design margin of 5%. The plot shows that the trials data follows the prediction fairly well at about 25 knots; however, at higher horsepower's the Savitsky method over-predicts the speed by about 2 knots. At full power the vessel achieved an average speed of 31.1 knots.

A proposed explanation for this divergence is a lack of sufficient bottom area to make up for the weight gain discussed above. The bottom area aft is reduced further due to the wide tunnels. The highly loaded bottom does not appear to produce sufficient lift for the vessel to fully reach a planing mode. This is reinforced by the earlier trials where the running trim was about 4 degrees. This was corrected by adding trim wedges which brought the running trim down to the predicted angle of about 2.5 degrees.

Also plotted as Figure 10 are curves of speed, range and fuel consumption vs. engine rpm based on the results of the acceptance trials.

Turning and Backing

When turning the rudders hard over at full speed the vessel was found to lean inboard initially, and then outboard to about 6 degrees as speed slowed. The equilibrium speed was roughly 20 knots and it took approximately 65 seconds to complete a 360 degree turn from the start of the maneuver. This corresponds to a turning radius of about 350', or 2.8 times the vessel's length. During turning the stabilizers were inactive.

A "quick reversal" was performed from full power and a speed of 30.7 knots in the ahead condition. The throttles were brought to neutral and then slowly into reverse. The time to full stop was about 32 seconds. The speed in reverse at 700 rpm's was 6.5 knots.

Stabilizers

The vessel was run with the stabilizers active and inactive at several speeds. The vessel's heading was set to roughly beam seas (+/- 30 degrees). The results of these tests are given in Table 5. All roll angles given are approximate averages and were recorded using the Naiad instrument panel and verified with an inclinometer.

Table 5 – Results of Stabilizer Testing

Speed (kts)	With Stabilizers	Without stabilizers
0	-----	4.5-5.0
9	1.5-2.0	3.0-3.5
12	1.5-1.7	1.5-2.5
15	1.3-1.5	2.2-2.6
24.5	0.7-0.9	1.2-2.0

Noise Levels

Noise levels were recorded during the delivery trip once the vessel was fully complete. Readings were taken with the vessel running at 28 knots and the engines at 1800 rpm. The air conditioning was running and all systems were functioning normally. Readings were taken in seas with a height of about 2'. These results are summarized in Table 6. All readings are based on A-scale weightings.

Table 6 – Noise Level Readings

Location	dB(A)
Pilothouse and sky lounge	62
Main salon	72
Dining room	66
Galley	65
Owner's stateroom	67
Owner's head	71
Mid-guest stateroom	62
Fwd-guest stateroom	65
Crew's quarters	90
Engine room	120
Cockpit	100
Flybridge	88

SUMMARY

The sportfishing yacht "Marlena" was a unique and challenging design. The lofty goals of the vessel required the builder to combine the elegance found on a first class motor yacht with the functionality of a high performance vessel. This challenge was all the greater for a commercial builder entering the luxury yacht market with only limited experience.

Many of the difficulties encountered may be familiar to designers and builders who have had experience with prototype vessels themselves. In particular, the ability to predict and control weights reinforces some very basic principles of naval architecture. While sometimes painful, these lessons are well worth reviewing from time to time.

While falling slightly short of the contract speed, the vessel met or exceeded all other expectations. More importantly, if judged by owner satisfaction, "Marlena" has certainly been a great success. Even now, as Mr. Gershowitz is just beginning to reap the rewards of his efforts, he is starting to consider the shape of his next yacht. Continuing to build on his growing experience, he is beginning to envision an even larger vessel. If this is the case, he may be the owner of the largest sportfishing yacht in the world for a long time to come.

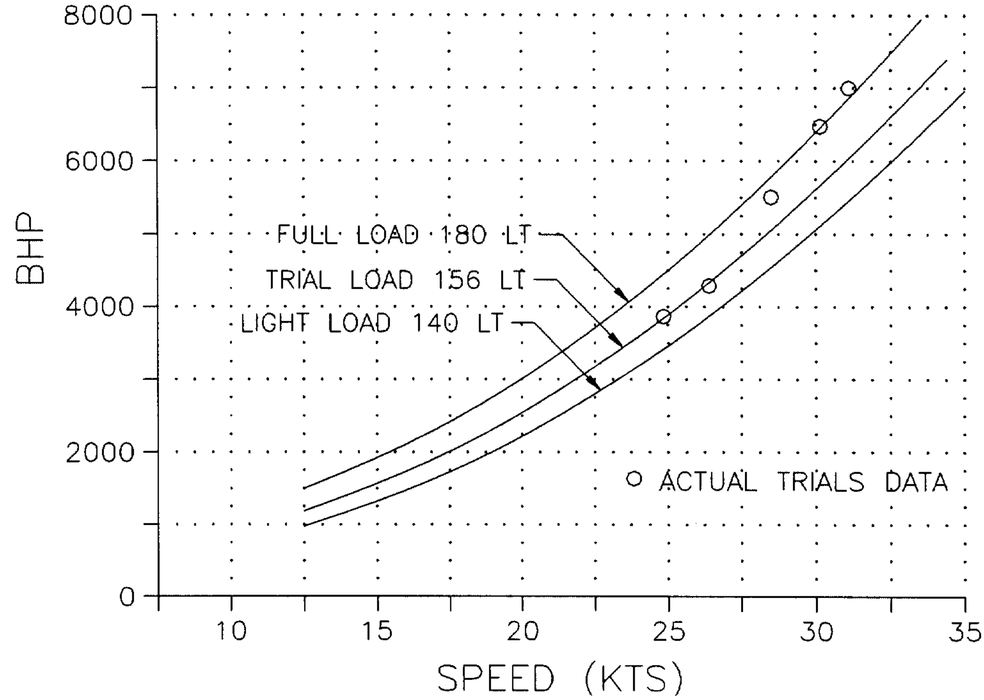


Figure 9: Plot of Speed vs. Power

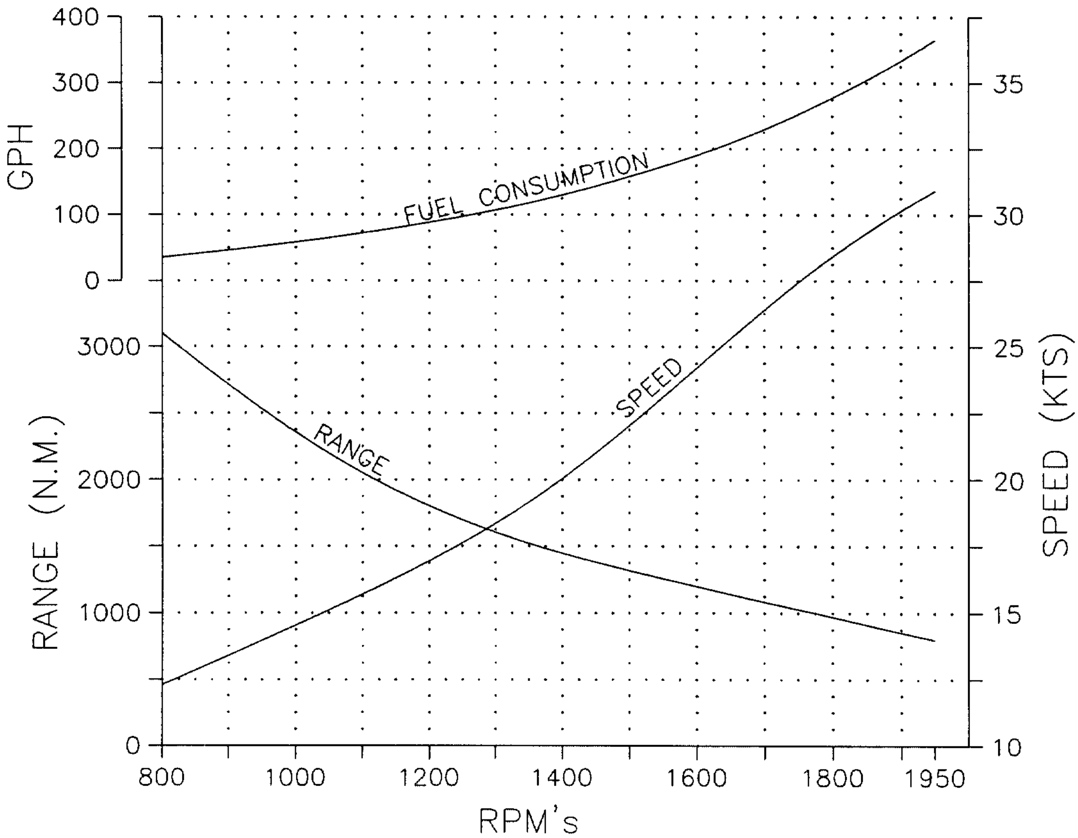


Figure 10: Plot of Range, Speed and Fuel Consumption vs. Engine RPM's

Figure 11: "Marlena" Running