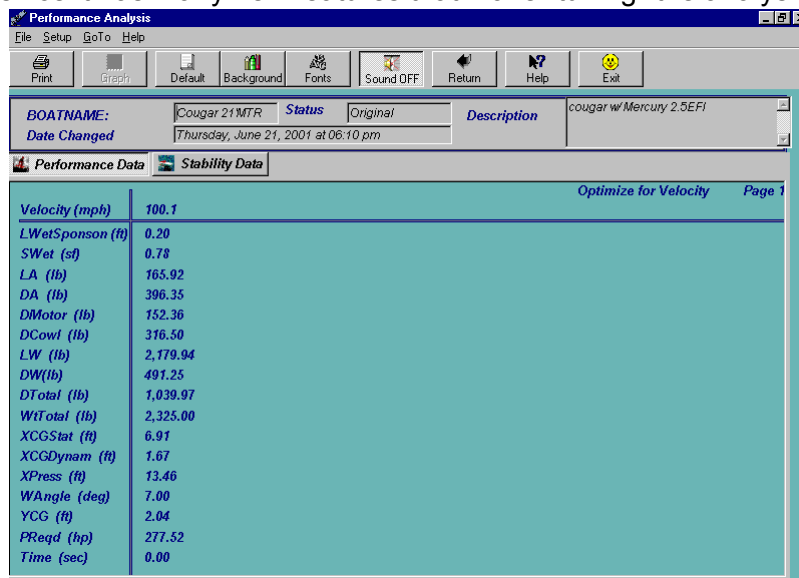




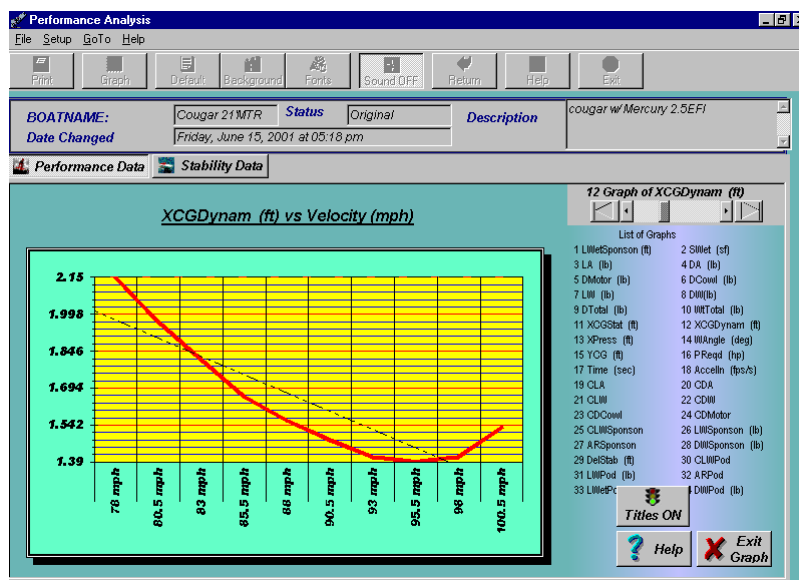
Cougar 21 MTR Performance Analysis

I wanted to do a "quick" analysis of top speed, and acceleration simulation. I used the (few) setup details from the boat test in F&PB's July 2001 issue. I admittedly, had to make some assumptions for many of the design and setup details that I was not aware of. The results should be, nevertheless, representative of the hull's capabilities. I used the new AeroMarine Research "Tunnel Boat Design Program", Version 6.3.3 for Windows 98 to do the analysis, since it has many new features that make "tuning" the analysis easy for top speed, acceleration



and stability simulation. Here are the results and a few of my conclusions from the analysis done. You'll note that the TBDP© results are very similar to those that the F&PB boat test recorded.

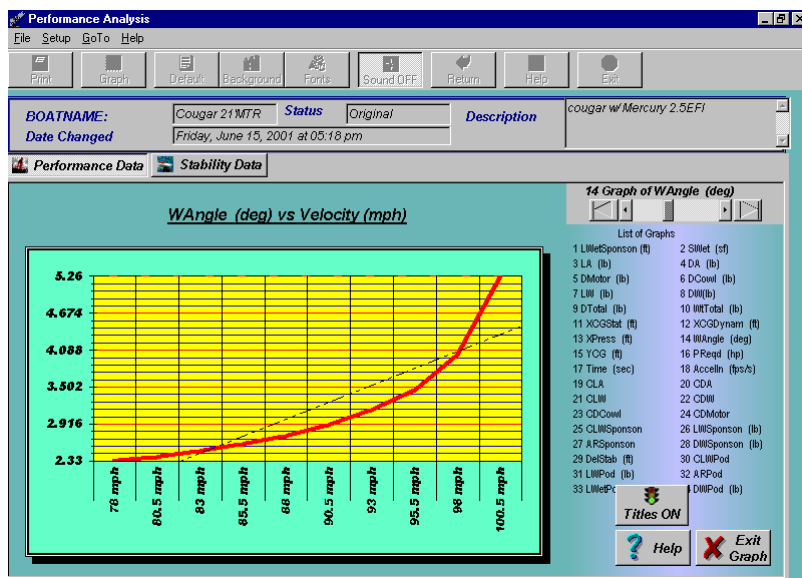
1. Top Speed is usually indicated by one or many of several performance parameters. I start by using the TBDP©'s "Velocity Optimizer" feature to predict maximum attainable velocity. By setting a purposely "too high" angle of attack (Wangle), the bounding maximum speed can be quickly approximated. **For the Cougar 21MTR, this comes out as 100.1 mph.** Sounds FAST, but for this hot boat, is reasonable. Further analysis can subsequently tell us more of the practical top speed.



2. Often one of the determining factors is stability. Since no tunnel hull can be inherently aerodynamically stable, I use a measure of stability that references the dynamic CG of the hull. This is the center of balanced

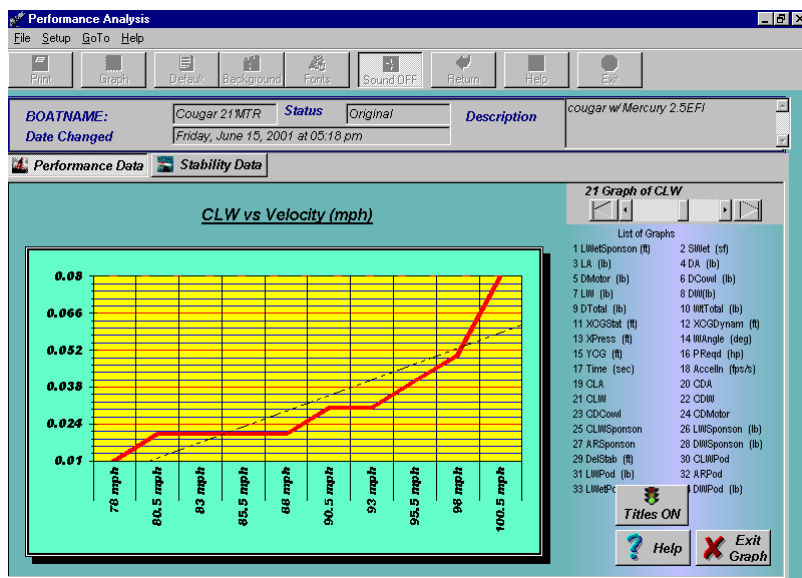


moments of all aerodynamic and hydrodynamic forces while the hull is under the specified running conditions, referenced fore (+) of the transom. The dynamic CG will change throughout the range of operating velocities. (To maximize stability at operating velocity, XCGDYNAM should be as close to the Static CG (deadweight balance) and ahead of the aerodynamic center, XPRESS). Well, this hull (like most tunnels) becomes inherently "unstable" at about 45mph, when the aerodynamic forces start becoming important. I define the stability measure as the change in the location of the dynamic CG with respect to the aerodynamic center. **We can see from the graph of XCGDYNAM (ft) vs. Velocity that the whole stability of the hull changes at around 95.5 mph and REALLY changes at 98 mph. This indicates the onset of this hull's instability.** (This is normal for all tunnel's...just at different speeds). There's more top speed indicator's...



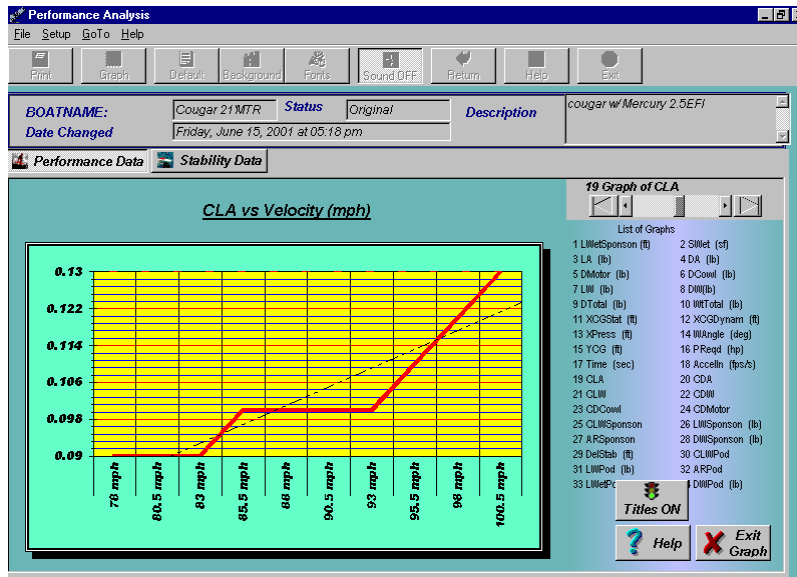
3. Of course tunnel boat drivers know that if you could keep giving it "up" trim forever without blowing over, the speed would be fantastic. The angle of attack that is required to attain higher velocities is shown in the graph Wangle (deg) vs Velocity. The graph shows that the required angle of attack of the Cougar 21MTR increases more and more as speed approaches 95 mph. At 98 mph the required angle of attack is 150% more than it was at 80 mph and the rate of change of the angle is now double what is was at 90

mph. **We can conclude that 98 mph is about the velocity where the driver will have to react very quickly, and should have driving skill and experience before driving at these speeds in this or any other boat.** There's still more indicators...

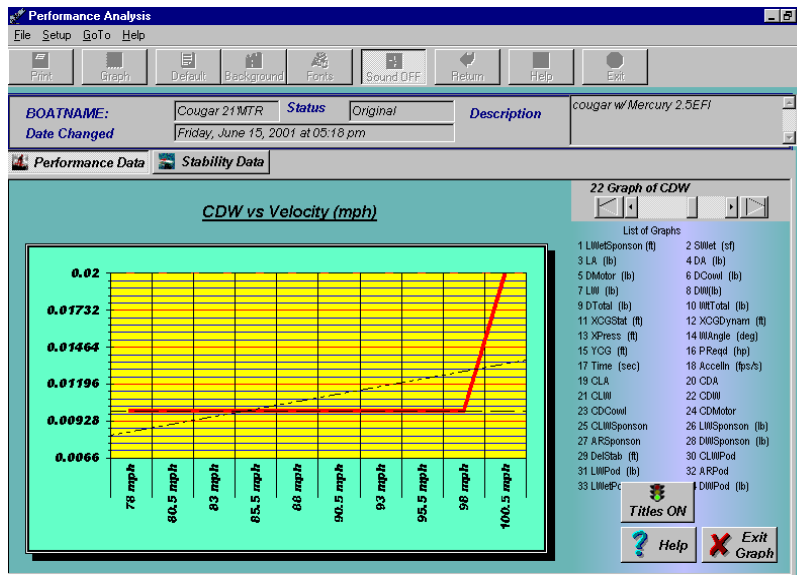


4. The coefficient of (total) Lift increases as the angle of attack increases. When the lift coefficient gets higher and higher, the boat finds it easier and easier to go faster. When the coefficient starts to increase quickly, it's time to be really careful. . The boat is going to see a lot more lift, and the driver will have to react much more quickly to compensate. This point of faster and faster increasing of (total) lift starts occuring with this design at about 93 mph, and becomes more pronounced at about 98 mph.





5. The coefficient of aerodynamic lift is somewhat stable up to about 90 mph, and then begins to increase a lot at about 93 mph. This means that the hull is going to find it ever easier to "fly".



6. There's another easy clue in the drag coefficient. If we look at the graph of the hydrodynamic drag coefficient (CDW vs Velocity), we see that the CDW really JUMPS up at 98 mph. The sponson lifting efficiency improves, which means that the boat will start to exhibit more instability than at lower speeds, as the sponsons "skip" across the wave surfaces, with this higher efficiency occurring intermittently - ON...OFF...ON...OFF. Tunnel drivers know that this feeling at

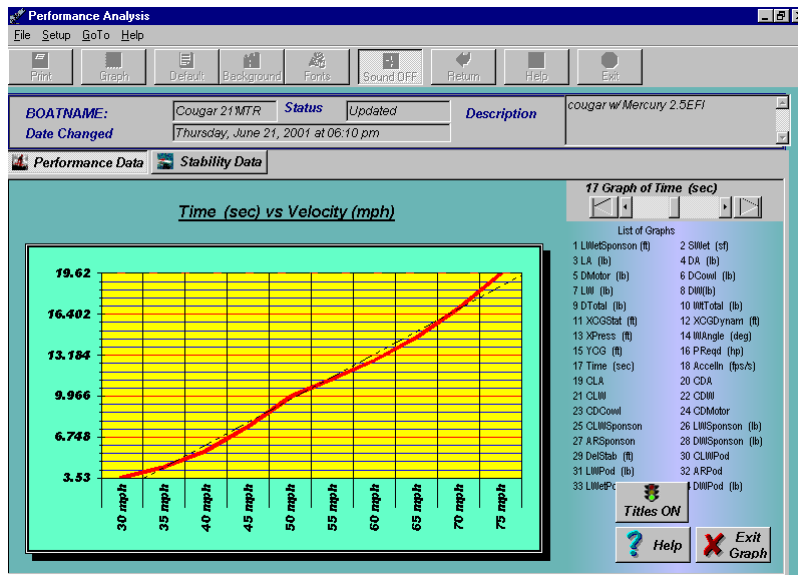
high speeds as a signal to pay very close attention.

So, conclusion: maximum velocity for this hull should be about 98 mph, with very good stability. It should have the capability of over 100 mph in good water conditions. What a great boat!

Let's look now at acceleration simulation...

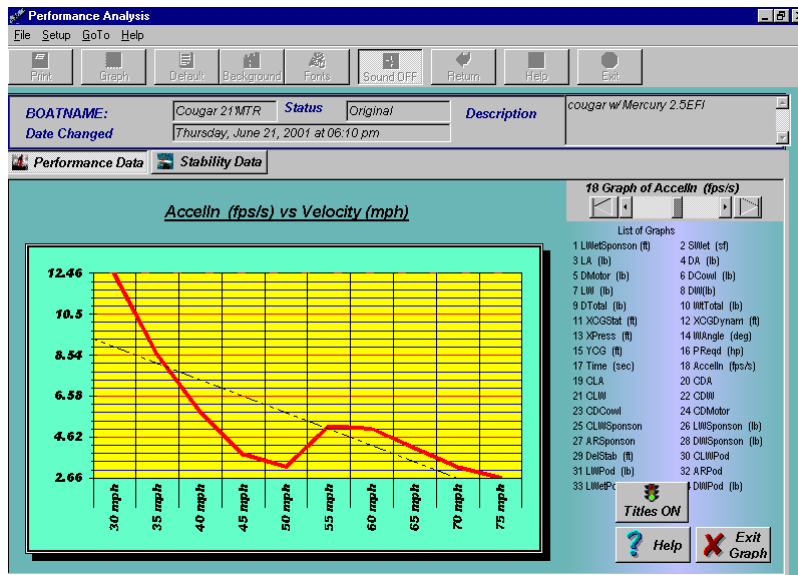


The TBDP© does a simulation of elapsed time and acceleration. Lot's of factors influence these performance characteristics. The TBDP assumes ideal hull/motor setup (maximum efficiency) and ideal driving skills.




7. I analysed the same velocity range that the F&PB did during their boat test. Based on some assumptions of a controlled increase in angle of attack (Wangle), we predict the elapsed times for acceleration through the 30 mph to 75 mph range to be as shown in the Graph "Time (sec) vs Velocity. The predicted elapsed times are very similar to those that were recorded in the boat test:

	TBDP© prediction	F&PB boat test
0-30 mph	3.53 sec	4.4 sec
to 40mph	5.64 sec	6.3 sec
to 50 mph	9.88 sec	8.4 sec
to 60 mph	12.77 sec	12.3 sec
to 70 mph	16.86 sec	17.2 sec



8. The acceleration graph is merely a result of the elapsed time analysis. It is interesting to see that the acceleration or rate of increasing velocity (ft per second per second) decreases up to about 50 mph, and then increases again. This intermediate velocity range (50 mph to 75 mph) of is called the *transition zone*, and exists on all tunnel boats, but is different for each hull and setup. I'll bet that John Cougar saw this transition happen at about 50 mph and lasti until 65-75 mph, with this rig.

Here's the design input and performance output that I got in my review of the Cougar 21MTR. 



TUNNEL BOAT DESIGN PROGRAM©

Version 6.3.3 - Copyright 1999-2001 by AeroMarine Research/Jim Russell



BoatName: Cougar 21'MTR

Description: cougar w/ Mercury 2.5EFI

Counter: 426

DateChanged: Thursday, June 21,2001 06:10 pm

Status: Updated

Page 2 (Printed Thursday, June 21,2001 06:11 pm)

Output Data: for Power optimization:

Velocity (Mph)	30	35	40	45	50	55	60	65	70	75
LWetSponson (ft)	21.00	21.00	21.00	21.00	15.51	8.40	6.27	4.86	3.74	2.72
SWet (sf)	249.15	169.13	120.19	88.50	59.98	32.50	24.25	18.78	14.47	10.52
LA (lb)	7.87	11.04	14.83	19.30	24.46	30.35	37.00	44.44	52.71	61.81
DA (lb)	35.72	48.61	63.47	80.32	99.15	119.95	142.73	167.48	194.22	222.92
DMotor (lb)	14.51	19.60	25.42	31.99	39.28	47.31	56.07	65.56	75.77	86.70
DCowl (lb)	28.45	38.72	50.57	64.00	79.01	95.61	113.78	133.54	154.87	177.78
LW (lb)	2,317.13	2,313.96	2,310.17	2,305.70	2,321.81	2,312.45	2,302.17	2,293.26	2,290.46	2,281.87
DW(lb)	2,450.39	2,242.71	2,067.56	1,917.76	1,705.68	1,328.80	1,148.37	1,054.21	974.74	877.26
DTotal (lb)	2,500.62	2,310.91	2,156.46	2,030.06	1,844.11	1,496.07	1,347.17	1,287.25	1,244.73	1,186.89
WtTotal (lb)	2,325.00	2,325.00	2,325.00	2,325.00	2,325.00	2,325.00	2,325.00	2,325.00	2,325.00	2,325.00
XCGStat (ft)	6.91	6.91	6.91	6.91	6.91	6.91	6.91	6.91	6.91	6.91
XCGDynam (ft)	10.79	10.78	10.78	10.78	8.06	4.54	3.51	2.86	2.37	1.93
XPress (ft)	10.37	10.49	10.61	10.73	10.84	10.95	11.06	11.17	11.28	11.38
WAngle (deg)	1.60	1.72	1.84	1.97	2.09	2.21	2.33	2.46	2.58	2.70
YCG (ft)	1.38	1.39	1.41	1.42	1.44	1.45	1.47	1.48	1.50	1.51
PReqd (hp)	200.05	215.69	230.02	243.61	245.88	219.42	215.55	223.12	232.35	237.38
Time (sec)	3.53	4.39	5.64	7.58	9.88	11.31	12.77	14.56	16.86	19.62
Accelln (fps/s)	12.46	8.59	5.84	3.78	3.19	5.15	5.02	4.09	3.18	2.66
CLA	0.0775	0.0798	0.0822	0.0844	0.0867	0.0889	0.0911	0.0932	0.0953	0.0974
CDA	0.0304	0.0303	0.0303	0.0303	0.0303	0.0302	0.0302	0.0302	0.0302	0.0302
CLW	0.0050	0.0054	0.0058	0.0062	0.0074	0.0113	0.0126	0.0139	0.0155	0.0185
CDW	0.0052	0.0052	0.0052	0.0051	0.0055	0.0065	0.0063	0.0064	0.0066	0.0071
CDCowl	0.0993	0.0993	0.0993	0.0993	0.0993	0.0993	0.0993	0.0993	0.0993	0.0993
CDMotor	0.0103	0.0102	0.0102	0.0101	0.0101	0.0100	0.0100	0.0099	0.0099	0.0099
CLWSponson	0.0048	0.0052	0.0056	0.0060	0.0076	0.0121	0.0134	0.0142	0.0154	0.0186
LWSponson (lb)	1,552.9	1,552.4	1,551.3	1,549.6	1,508.2	1,562.8	1,486.2	1,408.8	1,349.9	1,322.9
ARSponson	0.0745	0.0745	0.0745	0.0745	0.1101	0.2876	0.3167	0.3167	0.3387	0.4657
DWSponson (lb)	1,688.7	1,545.6	1,424.9	1,321.7	1,082.6	837.1	700.3	632.0	576.3	506.5
DelStab (ft)	0.4	0.3	0.2	0.0	-2.8	-6.4	-7.6	-8.3	-8.9	-9.5
CLWPod	0.0053	0.0057	0.0061	0.0065	0.0071	0.0099	0.0115	0.0133	0.0156	0.0184
LWPod (lb)	764.3	761.6	758.9	756.1	813.6	749.7	815.9	884.5	940.5	959.0
ARPod	0.0741	0.0741	0.0741	0.0741	0.0786	0.1421	0.1749	0.2163	0.2713	0.3523
LWetPod (lb)	18.0	18.0	18.0	18.0	17.0	9.4	7.6	6.2	4.9	3.8



TUNNEL BOAT DESIGN PROGRAM©

Version 6.3.3 - Copyright 1999-2001 by AeroMarine Research/Jim Russell

BoatName: Cougar 21'MTR

Description: cougar w/ Mercury 2.5EFI

Counter: 426

DateChanged: Thursday, June 21,2001 06:10 pm

Status: Updated

Page 1 (Printed Thursday, June 21,2001 06:11 pm)



Hull Design

1 TunnelHeight: 9 (inches)
3 WingChord 19 (feet)
5 PadWidth 12 (inches)
7 DeckWidth 89 (inches)

2 TunnelWidth 41 (inches)
4 WingThickness 10 (inches)
6 PadDeadrise 16 (degrees)

Steps

8 Step Selection One Step (selected)
10 StepLength2 (feet)

9 StepLength1 4 (feet)
11 StepHeight 0.25 (inches)

CentrePod

12 CtrPodSelect Yes (selected)
14 PodWidth 16 (inches)
16 PodHeight -1 (inches)

13 CtrPodLength 18 (feet)
15 PodDeadrise 12 (degrees)

Spray Rails

17 SprayHeight 5 (inches)
19 SprayFac 0.5 (factor)

18 SprayWidth 3.25 (inches)

AeroFoil

20 AngleInc 1 (degrees)

21 AeroType Low Camber (selected)

Lengths

22 BoatLength 21 (feet)
24 MotorLength -1 (feet)
26 MiscLength 2 (feet)

23 DriverLength 9.5 (feet)
25 FuelLength 2 (feet)
27 MotorHeight 36 (inches)

Weights

28 BoatWeight 1300 (pounds)
30 FuelWeight 300 (pounds)
32 MotorWeight 375 (pounds)

29 DriverWeight 200 (pounds)
31 MiscWeight 150 (pounds)

Cowlings/Cockpit

33 CowlType None (selected)
35 CowlHeightFront 12 (inches)

34 CowlHeightRear 12 (inches)
36 CowlWidth 55 (inches)

Design Analysis

37 Optimize Power (selected)
39 StartVelocity 30 (mph)
41 StartAngle 2.7 (degrees)

38 Accuracy 1 (percent)
40 VelocityInc 5 (mph)
42 Accel Model Straight-Line From (selected)

Conditions

43 PowerMax 280 (hp)
45 Altitude 100 (feet ASL)

44 PowerEffyFac 0.9 (percent)
46 WaterType Fresh (selected)

Drive Unit(s)

47 Number of Drives One Drive (selected)
49 SkegLength 10 (inches)
51 TorpedoDiam 4.75 (inches)
53 Drive Type Merc V6 (selected)

48 SkegWidth 9 (inches)
50 SkegThickness 0.2 (inches)
52 TorpedoLength 12 (inches)
54



MERCURY 2.5 EFI SPORT	
Engine Tested: Mercury 280 EFI Sport	Performance Test
Type: Two-stroke spark EFI	RPM MPH (Radar/GPS avg.)
Displacement: 153 cubic inches (2.5 liters)	1,000 5.1
Weight: 375 lbs. (advertised)	1,500 5.7
Optimum RPM range: 7,200-7,500	2,000 6.6
Gear Ratio: 1.87:1	2,500 18.0
Propeller: 14-1/2x30-inch Mercury Lightning ET	3,000 28.9
Jackplate: Bob's Machine hydroelectric	3,500 38.0
Setback: 6 inches	4,000 42.5
Weather Conditions	4,500 48.7
Air Temperature: 56 degrees F	5,000 55.6
Water Temperature: 49 degrees F	5,500 60.1
Wind: 5-10 mph	6,000 72.2
Humidity: 59 percent	6,500 82.9
Water conditions: 2- to 6-inch chop	7,000 88.7
	7,500 97.6
	7,600 102.0 (driver only)
	Top Speed: 97.6 mph @ 7,500 RPM (solo: 102 mph @ 7,600 rpm)
	0-30 mph: 4.4 seconds
	0-40 mph: 6.3 seconds
	0-50 mph: 8.4 seconds
	0-60 mph: 12.3 seconds
	40-60 mph: 5.9 seconds
	50-70 mph: 8.8 seconds

Base price: N/A (each boat custom-equipped)
 Price as tested: \$44,360
 Construction: Fiberglass/coremat/foam coring
 Interior: Two buckets and rear bench; 111x55-inch cockpit
 Length: 21 feet
 Beam: 89 inches
 Hull Weight: 920 lbs. bare (as advertised)
 Fuel Capacity: 30 gallons

From: Family & Performance Boating

**July 2001
Performance Test
Cougar 21 MTR**



www.aeromarineresearch.com
jimboat@aeromarineresearch.com

Copyright© 2001 AeroMarine Research®. All rights reserved.

No part of this report may be reproduced, transmitted, transcribed or translated into any language, in any form or by any means without the prior written permission of AeroMarine Research® or Jim Russell. Information in this report is subject to change without notice and does not represent a commitment on the part of AeroMarine Research®. AeroMarine Research® may make improvements and/or changes to this manual and/or in the Tunnel Boat Design Program software at any time. The Secrets of Tunnel Boat Design book® and the Tunnel Boat Design Program®, Version 6 for Windows 98/98se, is copyrighted by AeroMarine Research®.

