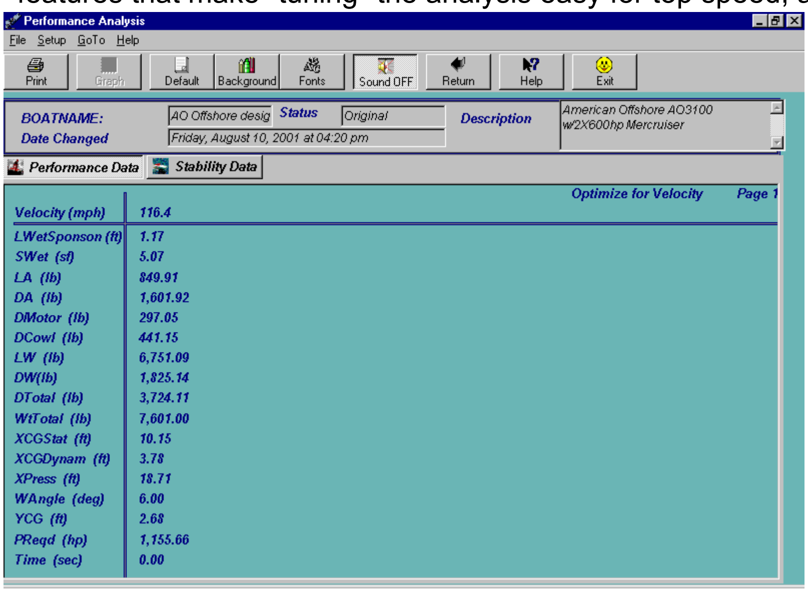
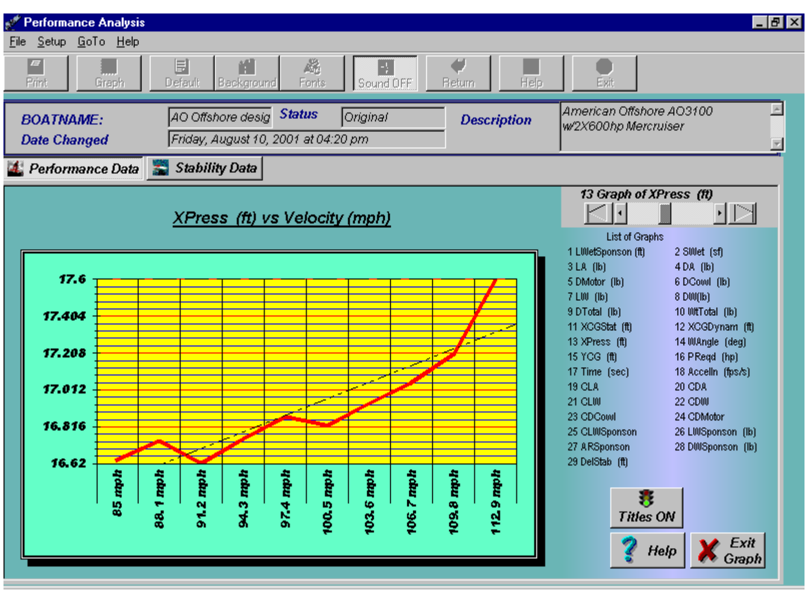
AeroMarine Research
TBDP Performance Boat Report

American Offshore 3100 Performance Analysis

We have done a short analysis of top speed, and acceleration simulation. I used some assumed setup details available from the boat test in Powerboat Magazine's June 2000 issue, and also from the excellent American Offshore website. The results should be, nevertheless, representative of the hull's capabilities. I used the new AeroMarine Research "Tunnel Boat Design Program", Version 6.3.2 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 see that the TBDP© results are very similar to those that the Powerboat Mag boat test recorded. You'll also see that the AO3100 is one fantastic boat!

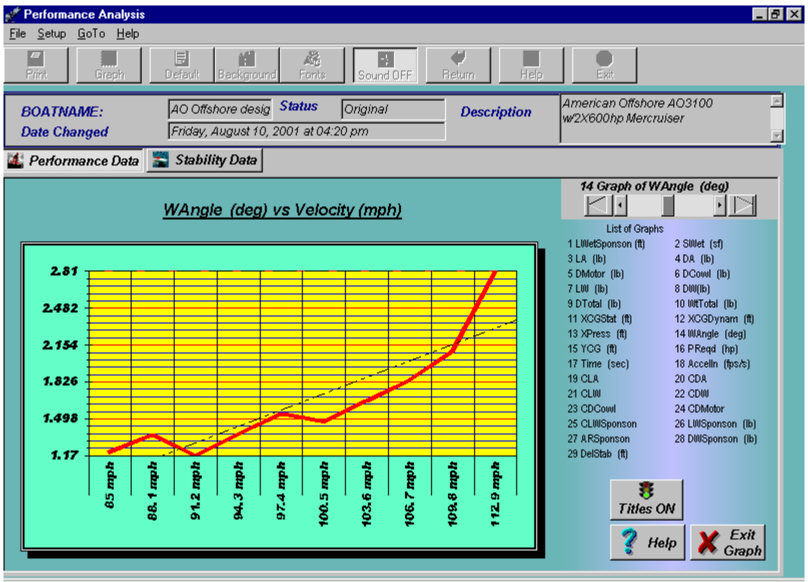




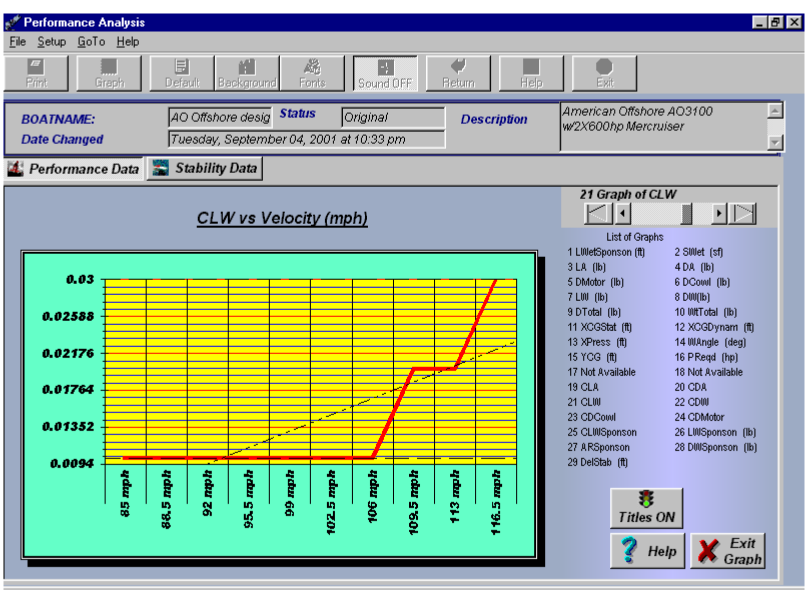
1. Top Speed is usually indicated by one or many of several performance variables. I start by using the TBDP©'s "Velocity Optimizer" feature to predict maximum attainable velocity with the two 600 hp motors. By setting a "high" angle of attack (Wangle), the bounding maximum speed can be quickly approximated. ***For the American Offshore AO3100, this comes out as <u>116.4 mph</u>***. This is a pretty high velocity, but I'm familiar with the AO design, and it's an incredibly fast hull! Further analysis can tell us more of the practical top speed.

2. Often one of the determining factors is stability. Since a tunnel hull cannot be inherently aerodynamically stable, I use a measure of stability that references the dynamic CG of the hull, using in part, the

aerodynamic center of pressure from the "wing" or aerofoil of the hull (referenced fore (+) of the transom). The dynamic CG and the center of pressure (XPRESS) will change throughout the range of operating velocities. (To maximize stability at operating velocity, dynamic CG should be ahead of the aerodynamic center, XPRESS). Well, this hull (like most tunnels) becomes inherently unstable at about 60 mph, when the aerodynamic forces start becoming more important. In this case, I can define the stability measure as the _change_ in the location of the XPRESS. We can see that XPRESS is constantly moving forward (getting more unstable), but as long as this change is at a reasonably slow and _constant_ rate, the driver will be able to compensate. This hull maintains a remarkably consistent rate of change in XPRESS, indicating that it will have a very stable "feel" to it throughout it's velocity range. ***We can see from the graph of XPRESS (ft) vs. Velocity that the stability of the hull changes at around _113 mph_. This indicates the onset of this hull's "instability"***. There's more top speed indicator's…

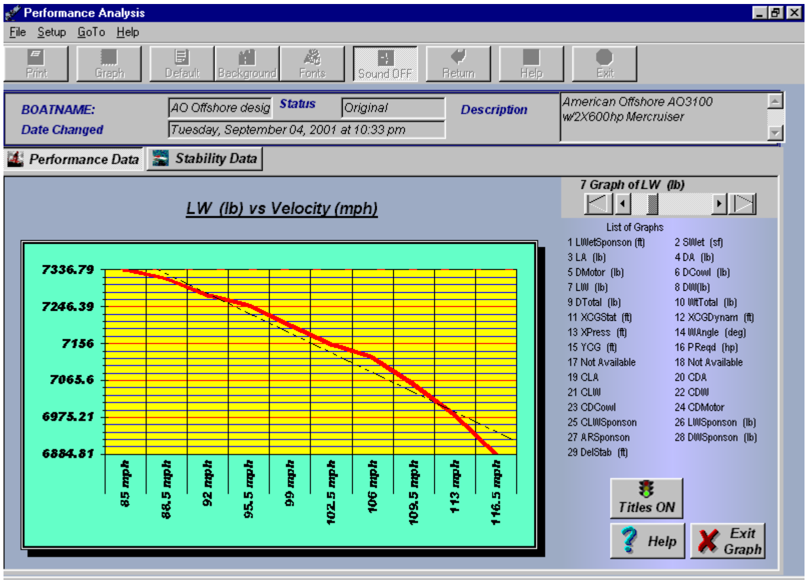


3. Of course tunnel boat drivers know that if you could keep giving it "up" trim forever without blowing over, the speed would be fantastic. (On large tunnels like this one, however, as the outdrives are trimmed up, speed increases until the angle of attack reaches a point where prop slip ultimately increases and hull speed can actually fall off before reaching the point of blow over). 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 American Offshore AO3100 increases more and more as speed approaches 100 mph. At 113 mph the _required_ angle of attack is 2X more than it was at 85-90 mph and the _rate of_ change of the angle is now 4X what is was at 85-90 mph. ***We can conclude that _110 mph_ is about the velocity where the driver will have to react more quickly, and should have driving skill and experience before driving at these speeds in this or any other boat.*** There's still more indicators…

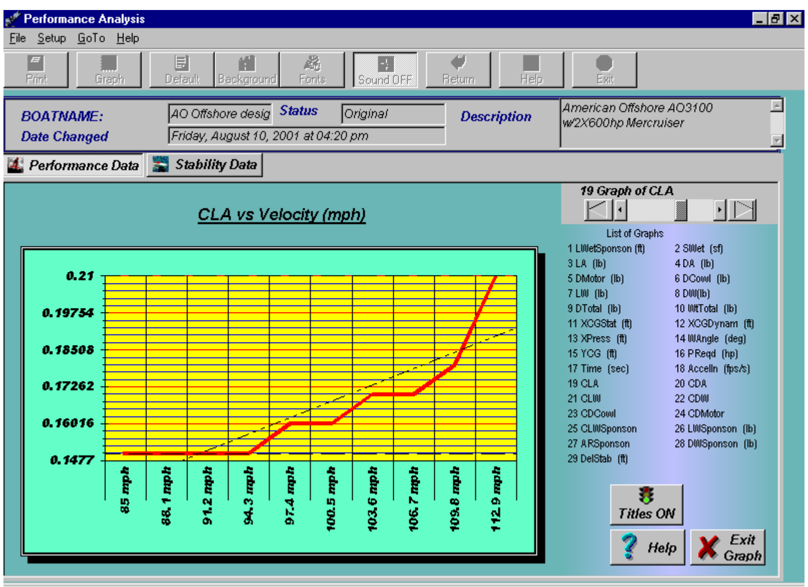


4. There's another easy clue in the sponson lift coefficient. If we look at the graph of the hydrodynamic lift coefficient (CLW vs. Velocity), we see that the CLW really jumps up at about

106 mph, and again at 112 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.

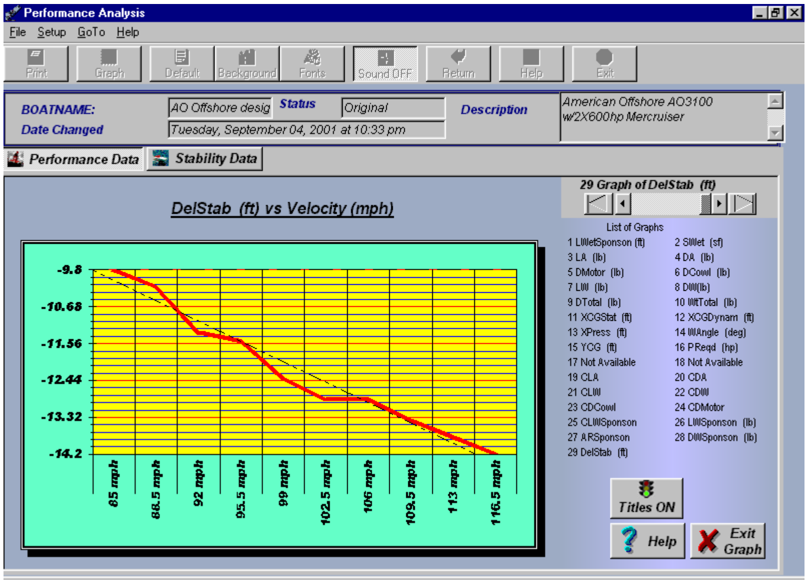


5. The hydrodynamic (water) lift (LW) decreases as the aerodynamic (air) lift (LA) becomes more significant. For speed, this is a good thing – and is the beauty of the tunnel hull design. The sponson (and lower unit drives) contact with the water, however, is the best control surface the hull has. As the LW decreases, the boat "flies" more. The rate at which LW decreases is a good indication of stability. Our case shows the rate of decrease becoming more prominent at 106 mph, and even more advanced at 112 mph. This is the stage at which and the driver will have to react much more quickly to compensate for having more aerodynamic lift, and less (LW) control surface.



6. The coefficient of aerodynamic lift (CLA) is very stable up to about 94 mph, then begins to increase a lot at about 97 mph, and starts to intensify at an increasing rate at about 110 mph. This means that the hull is going to find it ever easier to "fly". We saw the impact of this earlier, when we looked at the hydrodynamic lift (LW), showing that our conclusions are consistent.

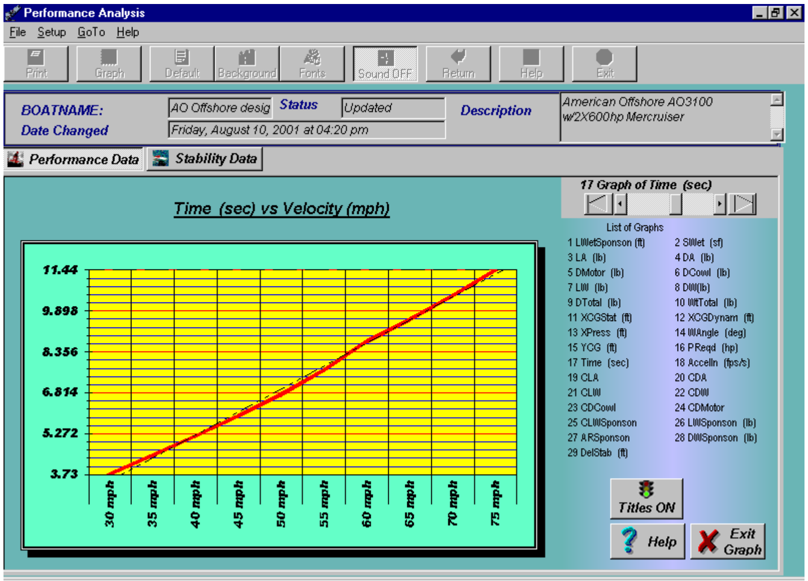
So, conclusion: ***maximum velocity for this hull should be a relatively easy 110 mph, with very good stability. It should have the capability of over 115 mph in good water conditions. WOW - what a machine!***



7. There's a further note that I feel is worth amplifying for this hull. I pointed out earlier that I use a measure of stability that references the dynamic CG of the hull (the centre of balanced moments of all forces under running conditions). This 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 centre, XPRESS). This ideal situation is pretty well impossible for any boat, and so the rate of change of the XCGDYNAM compared to the XPPRESS is a great measure of how challenging the hull will be to maintain stability. This "change" is called DELSTAB vs. Velocity, and is shown in the chart below. **The observation here, is that the AO3100 exhibits no dramatic changes in DELSTAB through the critical high speed operating range. This will make the "feel" of the hull one of stability, and will contribute to a more confident ride, with good control, by the driver.**

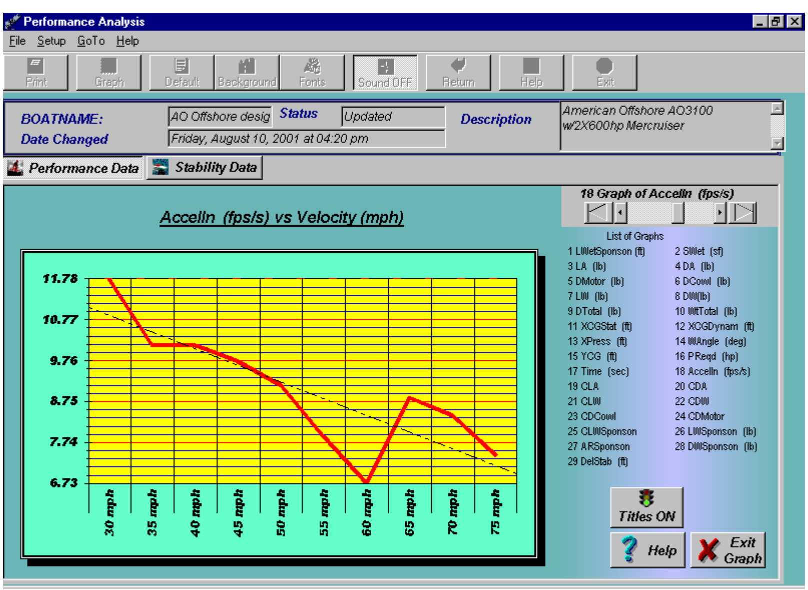
Let's look now at acceleration simulation …

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.



8. I analysed the same velocity range that the PB Mag 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". **In short, this is one <u>quick</u> boat.** The predicted elapsed times are very similar to those that were recorded in the boat test:

	TBDP© Prediction	PB Mag Boat test
0 - planing speed (about 45 mph)	3.3 sec	2.9 sec
0 - 98 mph	21.64 sec	20.0 sec
30 to 50 mph	3.01 sec	3.4 sec
40 to 60 mph	3.57 sec	3.3 sec
40 to 70 mph	5.27 sec	5.2 sec



9. 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 (feet per second per second) decreases up to about 55 mph, and then <u>increases</u> again at 60 mph. This intermediate velocity range (50 mph to 75 mph) is called the *transition zone*, and exists on all tunnel boats, but is different for each hull and setup. I'll bet that the Powerboat Mag boys saw this "transition" (often experienced on tunnel boats as porpoising) start at about 50 mph and lasting until 65-75 mph, with this rig.

Here's the design input and performance output that I got in my review of the American Offshore AO3100.

TUNNEL BOAT DESIGN PROGRAM©
Version 6.3.2 - Copyright 1999-2001 by AeroMarine Research/Jim Russell
BoatName: AO Offshore design
Description: American Offshore AO3100 w/2X600hp Mercruiser
Counter: 348 **DateChanged: Friday, August 10,2001 04:20 pm**
Status: Updated **Page 1 (Printed Friday, August 10,2001 04:24 pm)**

Hull Design					
1 TunnelHeight:	16	(inches)	2 TunnelWidth	41	(inches)
3 WingChord	26	(feet)	4 WingThickness	31	(inches)
5 PadWidth	24	(inches)	6 PadDeadrise	18	(degrees)
7 DeckWidth	102	(inches)			
Steps					
8 Step Selection	Two Steps	(selected)	9 StepLength1	6.5	(feet)
10 StepLength2	6.5	(feet)	11 StepHeight	1.5	(inches)
CentrePod					
12 CtrPodSelect	No	(selected)	13 CtrPodLength	20	(feet)
14 PodWidth	16	(inches)	15 PodDeadrise	12	(degrees)
16 PodHeight	-1	(inches)			
Spray Rails					
17 SprayHeight	5	(inches)	18 SprayWidth	3.25	(inches)
19 SprayFac	0.5	(factor)			
AeroFoil					
20 AngleInc	1.3	(degrees)	21 AeroType	Zero Camber	(selected)
Lengths					
22 BoatLength	30	(feet)	23 DriverLength	12	(feet)
24 MotorLength	2.5	(feet)	25 FuelLength	10	(feet)
26 MiscLength	15	(feet)	27 MotorHeight	18	(inches)
Weights					
28 BoatWeight	4000	(pounds)	29 DriverWeight	300	(pounds)
30 FuelWeight	700	(pounds)	31 MiscWeight	1	(pounds)
32 MotorWeight	2600	(pounds)			
Cowlings/Cockpit					
33 CowlType	None	(selected)	34 CowlHeightRear	12	(inches)
35 CowlHeightFront	7	(inches)	36 Cockpit Width	92	(inches)
Design Analysis					
37 Optimize	Power	(selected)	38 Accuracy	5	(percent)
39 StartVelocity	30	(mph)	40 VelocityInc	5	(mph)
41 StartAngle	2	(degrees)	42 Accel Model	User Fit	(selected)
Conditions					
43 PowerMax	1200	(hp)	44 PowerEffyFac	0.9	(percent)
45 Altitude	100	(feet ASL)	46 WaterType	Salt	(selected)
Drive Unit(s)					
47 Number of Drives	Two Drives	(selected)	48 SkegWidth	6	(inches)
49 SkegLength	6	(inches)	50 SkegThickness	0.2	(inches)
51 TorpedoDiam	4	(inches)	52 TorpedoLength	12	(inches)
53 Drive Type	Input Outboard	(selected)	54		

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BoatName: AO Offshore design
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Status: Updated **Page 2 (Printed Friday, August 10,2001 04:24 pm)**

Output Data: for Power optimization:

Velocity (Mph)	30	35	40	45	50	55	60	65	70	75
LWetSponson (ft)	30.00	30.00	30.00	30.00	30.00	30.00	29.69	15.85	12.26	9.66
SWet (sf)	1,154.69	728.22	466.72	315.62	222.58	167.20	128.50	68.60	53.08	41.82
LA (lb)	23.52	33.80	47.17	63.43	82.80	104.17	128.61	156.27	189.28	226.25
DA (lb)	105.47	143.55	187.50	237.30	292.96	354.48	421.86	495.11	574.20	659.16
DMotor (lb)	20.66	27.95	36.34	45.80	56.34	67.95	80.63	94.38	109.19	125.07
DCowl (lb)	29.32	39.91	52.12	65.97	81.44	98.54	117.28	137.64	159.63	183.24
LW (lb)	7,577.48	7,567.21	7,553.83	7,537.57	7,518.20	7,496.83	7,529.19	7,444.73	7,411.72	7,374.75
DW(lb)	11,783.58	10,027.22	8,367.53	7,161.06	6,250.63	5,689.56	5,231.56	4,015.18	3,538.23	3,264.57
DTotal (lb)	11,909.70	10,198.72	8,591.37	7,444.16	6,599.92	6,111.99	5,734.05	4,604.66	4,221.62	4,048.80
WtTotal (lb)	7,601.00	7,601.00	7,601.00	7,601.00	7,601.00	7,601.00	7,601.00	7,601.00	7,601.00	7,601.00
XCGStat (ft)	10.15	10.15	10.15	10.15	10.15	10.15	10.15	10.15	10.15	10.15
XCGDynam (ft)	15.44	15.40	15.37	15.35	15.36	15.38	15.25	8.48	6.80	5.63
XPress (ft)	15.92	16.03	16.18	16.33	16.47	16.57	16.67	16.77	16.90	17.03
WAngle (deg)	0.20	0.35	0.55	0.75	0.95	1.10	1.25	1.40	1.60	1.80
YCG (ft)	1.74	1.77	1.80	1.83	1.87	1.89	1.91	1.94	1.97	2.00
PReqd (hp)	952.78	951.88	916.41	893.30	879.99	896.42	917.45	798.14	788.04	809.76
Time (sec)	3.73	4.46	5.18	5.93	6.74	7.66	8.75	9.58	10.45	11.44
Accelln (fps/s)	11.78	10.14	10.14	9.74	9.15	7.89	6.73	8.84	8.41	7.44
CLA	0.1182	0.1247	0.1333	0.1416	0.1497	0.1557	0.1615	0.1672	0.1747	0.1819
CDA	0.0412	0.0412	0.0412	0.0412	0.0412	0.0412	0.0412	0.0412	0.0412	0.0412
CLW	0.0034	0.0040	0.0047	0.0055	0.0063	0.0069	0.0076	0.0120	0.0133	0.0146
CDW	0.0053	0.0053	0.0052	0.0052	0.0052	0.0053	0.0053	0.0065	0.0064	0.0065
CDCowl	0.0524	0.0524	0.0524	0.0524	0.0524	0.0524	0.0524	0.0524	0.0524	0.0524
CDMotor	0.0159	0.0158	0.0157	0.0157	0.0156	0.0156	0.0155	0.0155	0.0154	0.0154
CLWSponson	0.0034	0.0040	0.0047	0.0055	0.0063	0.0069	0.0076	0.0120	0.0133	0.0146
LWSponson (lb)	7,577.5	7,567.2	7,553.8	7,537.6	7,518.2	7,496.8	7,529.2	7,444.7	7,411.7	7,374.8
ARSponson	0.1273	0.1273	0.1273	0.1273	0.1273	0.1273	0.1297	0.3330	0.3330	0.3330
DWSponson (lb)	11,783.6	10,027.2	8,367.5	7,161.1	6,250.6	5,689.6	5,231.6	4,015.2	3,538.2	3,264.6
DelStab (ft)	-0.5	-0.6	-0.8	-1.0	-1.1	-1.2	-1.4	-8.3	-10.1	-11.4
CLWPod										
LWPod (lb)										
ARPod										
LWetPod (lb)										

POWERBOAT MAGAZINE – June 2000

American **Offshore-3100**

In a group of boats with color schemes louder than their big-block engines, standing out can be a matter of keeping things simple-at least in terms of graphics. That's precisely what American Offshore did with the 3100 it sent to our roundup. The 305"-long 8'6" wide cat came decked in simple white gelcoat, with light, vinyl tape-applied striping. And darn if the bright-white boat didn't pop out in this sea of psychedelia.

With a pair of MerCruiser 7.4L MPI powerplants under the hatch, base price for the 3100 is $99,380. Headquartered in Dickson, Texas, American Offshore builds its own custom motors, and our test boat came equipped with two 600-hp beasts, a number of additional upgrades and a $167,508 sticker.

The company based the engines on 502- cubic-inch General Motors' blocks to which it added Blower Shop 871 blowers, aluminum heads and stainless-steel valves, Dan Olsen coolers and Stainless Marine exhaust systems. (No intercooling for the blowers was provided.) For drives, the manufacturer went with stock Bravo One units twirling lab-finished Bravo One 15 1/4" x 32" four blade stainless-steel propellers through a 1.3 1 reduction.

Streaking along at 102.3 mph at 5600 rpm, the 3100 was a white blur. Two engines and eight propeller blades made for the best standing-start and mid-range acceleration numbers of any cat in the roundup, starting with a 2.9-second time to plane and a speed of 98 mph in 20 seconds. The 3100 simply blasted from 30 to 50 mph in 3.4 seconds, from 40 to 60 in 3.3 seconds and from 40 to 70 mph in 5.2 seconds.

From: Powerboat Magazine
June 2000
Performance Test
American Offshore 3100

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Get your fully illustrated, 13th edition copy of the "***Secrets of Tunnel Boat Design***" book, with over 200 pages of design practices and formulae and over 150 photographs.

The publications "History of Tunnel Boat Design" book, "Secrets of Propeller Design " book, the "Tunnel Boat Design Program©" software, and the "PropWorks2" software for speed prediction and propeller selection are available at the AeroMarine Research web site. http://www.aeromarineresearch.com

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"Secrets of Propeller Design©" book - http://www.aeromarineresearch.com/historyofpropellers.html

"Tunnel Boat Design Program© ", V7 software - http://www.aeromarineresearch.com/tbdp6.html

"Vee Boat Design Program© " software - http://www.aeromarineresearch.com/vbdp.html

"PropWorks2©" software for propeller selection and powerboat speed prediction - http://www.aeromarineresearch.com/prop2.html

About AeroMarine Research:

Jim Russell is a professional engineer with a mechanical and aeronautics background. Currently living in Canada, he has done extensive aerodynamic research at University of Michigan, OH and University of Toronto, Canada and marine research at the NRC water channel laboratory in Ottawa, Canada. His published works and papers are highly acclaimed, and are specifically related to the aerodynamics and hydrodynamics of high performance catamarans and tunnel boats, vee and vee-pad hulls. Russell has designed and built many tunnel and performance boats. As a professional race driver, he piloted tunnel boats to Canadian and North American championships. He has written power boating articles for many worldwide performance magazines and has covered UIM and APBA powerboat races. He has appeared on SpeedVision's '*Powerboat Television'* as a guest expert on 'Tunnel Hulls', was performance/design technical consultant on National Geographic's '*Thrill Zone*' TV show, and editorial consultant on Discovery Channel's '*What Happened Next*' TV show. Russell is the author of the "Secrets of Tunnel Boat Design©" book, "The Wing in Ground Effect - Their relation to Powerboats©", book, and the "Secrets of Propeller Design©" book. His company has designed and published the well-known powerboat design software, "Tunnel Boat Design Program©" and "Vee Boat Design Program©" specifically for the design and performance analysis of tunnel boats, powered catamarans, performance Vee and Vee-Pad hulls.

Notes about this Report: The considerations addressed in this report are for a high performance powerboat design and application and thus results are highly dependent on detailed specifics of the hull design, modifications, construction, hull setup and operation, and other factors that are not within the scope of this report. The TBDP©/VBDP© software uses proven engineering algorithms to predict performance of planing hull designs of different configurations and lends itself well to comparative performance analysis. The software provides typical predictive performance data to aid in making design comparisons which may be helpful toward making design decisions.

Since the existing design of the hull, any subsequent modifications, and ultimate performance is complex, this performance review, this report and included recommendations are for your information only and cannot guarantee the results.