

SAILING THE  
**DOWNWIND CLIFF**

Mark Croll

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# Historical Context



# Historical Context



# Historical Context



# Good Upwind Leg





# Had a Good Upwind Leg The Most Beautiful Sight in Sailing Spinnakers Behind - Happy



# Spinnakers in Front Not so Pretty - Sad



# Tweet from Trump



**Donald J. Trump** ✓

@realDonaldTrump

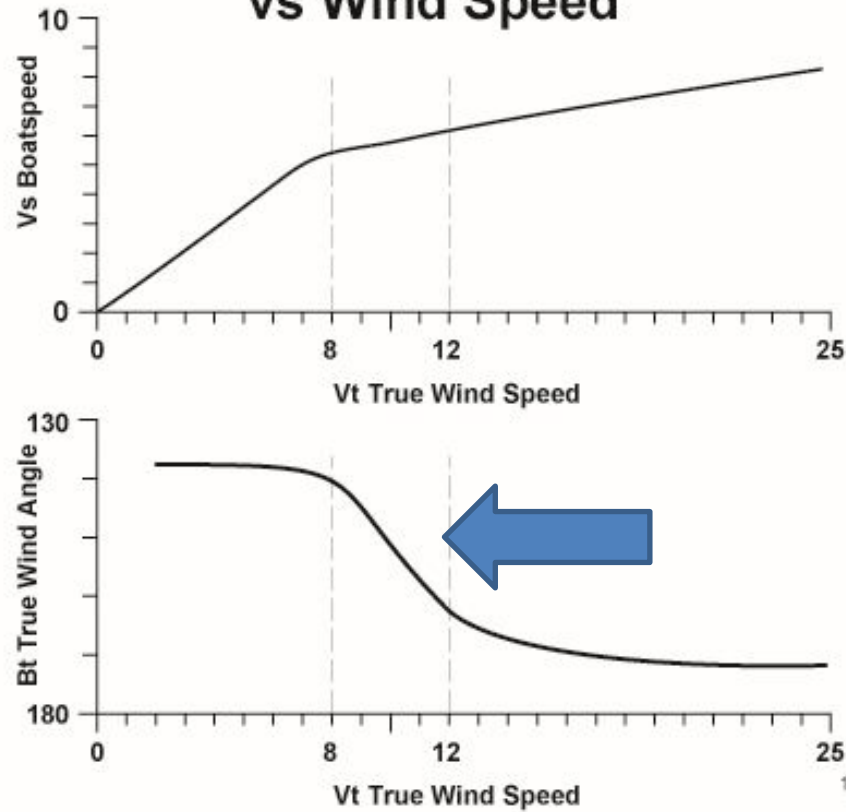
President-elect of the United States

Mark, terrible downwind leg. So sad. My grandson could do better.  
Maybe I can help.  
#don't jump off the cliff



# What is our Cliff

Figure 4-12  
Downwind Targets  
vs Wind Speed



# Do Definitions Help

- The **Downwind Cliff** is the change in **downwind** tacking (gybing) angle with wind speed that changes your tactics. – Ockam
- Or according to Wikipedia, This "downwind cliff" (abrupt change in optimum downwind course) results from the change of balance in drag forces on the hull with speed. [\[33\]](#)
- 33 Textor, Ken (1995). [The New Book of Sail Trim](#). Sheridan House, Inc. p. 228. [ISBN 0924486813](#).

# Why this Non-linearity in 8 -12 knot Range

- At these wind speeds in the vertical range of the atmosphere that we sail in, (0 – 100 feet) the wind changes from laminar flow to turbulent flow, creating much more power
- Bethwaite, Frank – High Performance Sailing, Second Edition, 2010 pp 10-19.
- Boat speed increases and hull resistance builds up - Textor
- Sails go from lift mode (wings) to drag mode (parachutes) - Ockam

# Boat and Sails

- Below about 8 knots, the boat is comfortably below hull speed and produces less drag. Because this is a lower load on the sails, they still act as wings, giving you lift, and allowing you to point higher (let's call that downwind angle).
- Between 8 and 12 knots, the hull resistance builds up, and the sails begin to transition to drag mode. As a result, your downwind angle gets less fairly quickly the beginning of the downwind cliff.
- Above 12 knots, the sails are in full drag mode, and your downwind angle gets small. You are at the bottom of the cliff now.
- Ockam Instruments - 2014

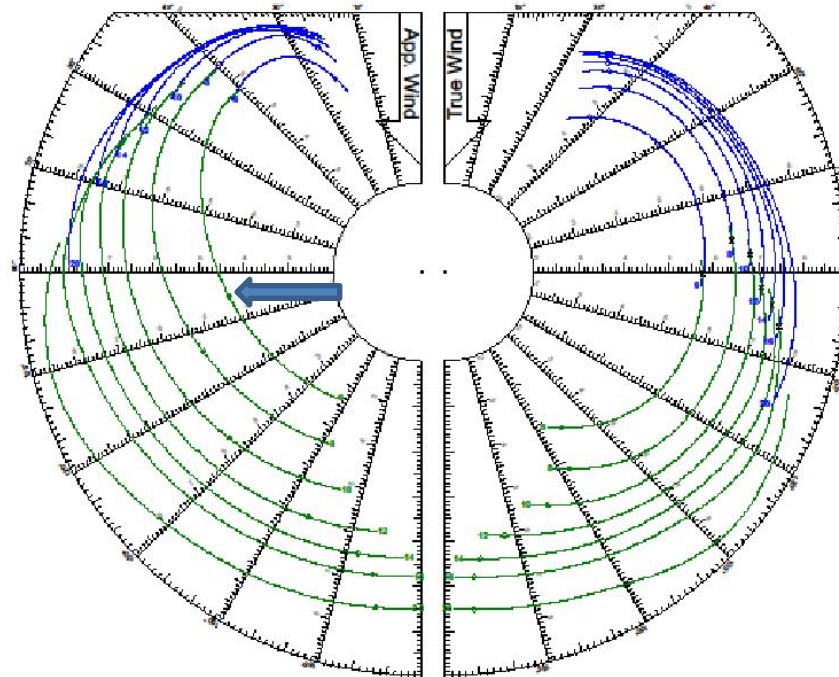
# Wind Regimes

- Regime 1 Light Air
- Remember that in this regime, the sails are still airfoils, not parachutes. This means you have to watch out for “stalls”, where the flow on the sails breaks. When this happens, you have to head up to reestablish flow. Having a polar diagram will help prevent you from going too deep and stalling out.
- Regime 3 Heavy Air
- Another thing is that the sails are now parachutes, and maintaining air flow is not a problem.
- Regime 2 Transitional
- Here the sails change from lift to drag mode in a few knots of wind speed. Boat handling changes in and out of flow maintenance, increasing the need for concentration.
- Ockam Instruments - 2014

# View from a Polar Diagram



## Speed Guide

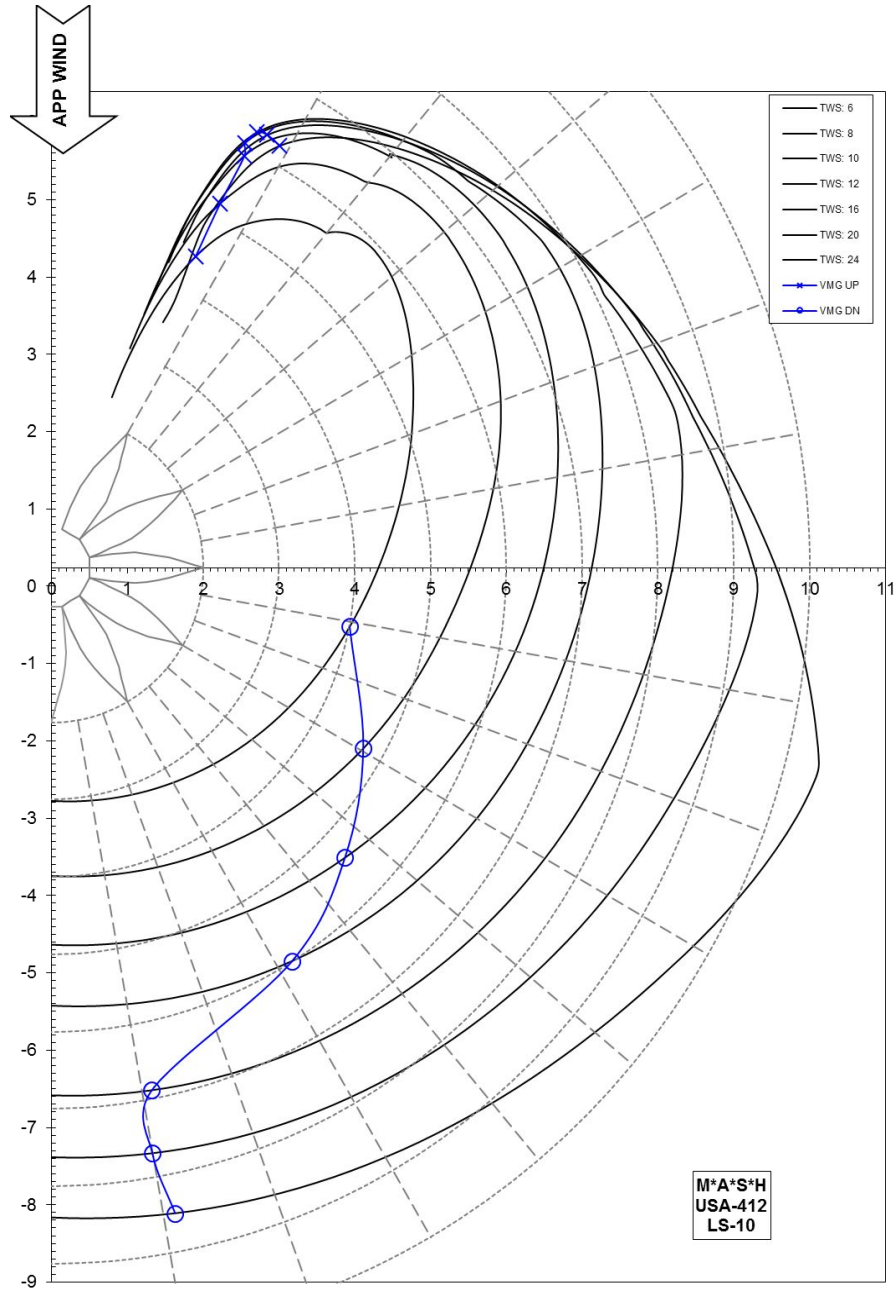


Polar Plot for Boat	
Name	
Sail Number	
Class	TARTAN 10-EST
Designer	S&S
Builder	TARTAN
Issued On	4/7/2012 - VPP 2012 1.01

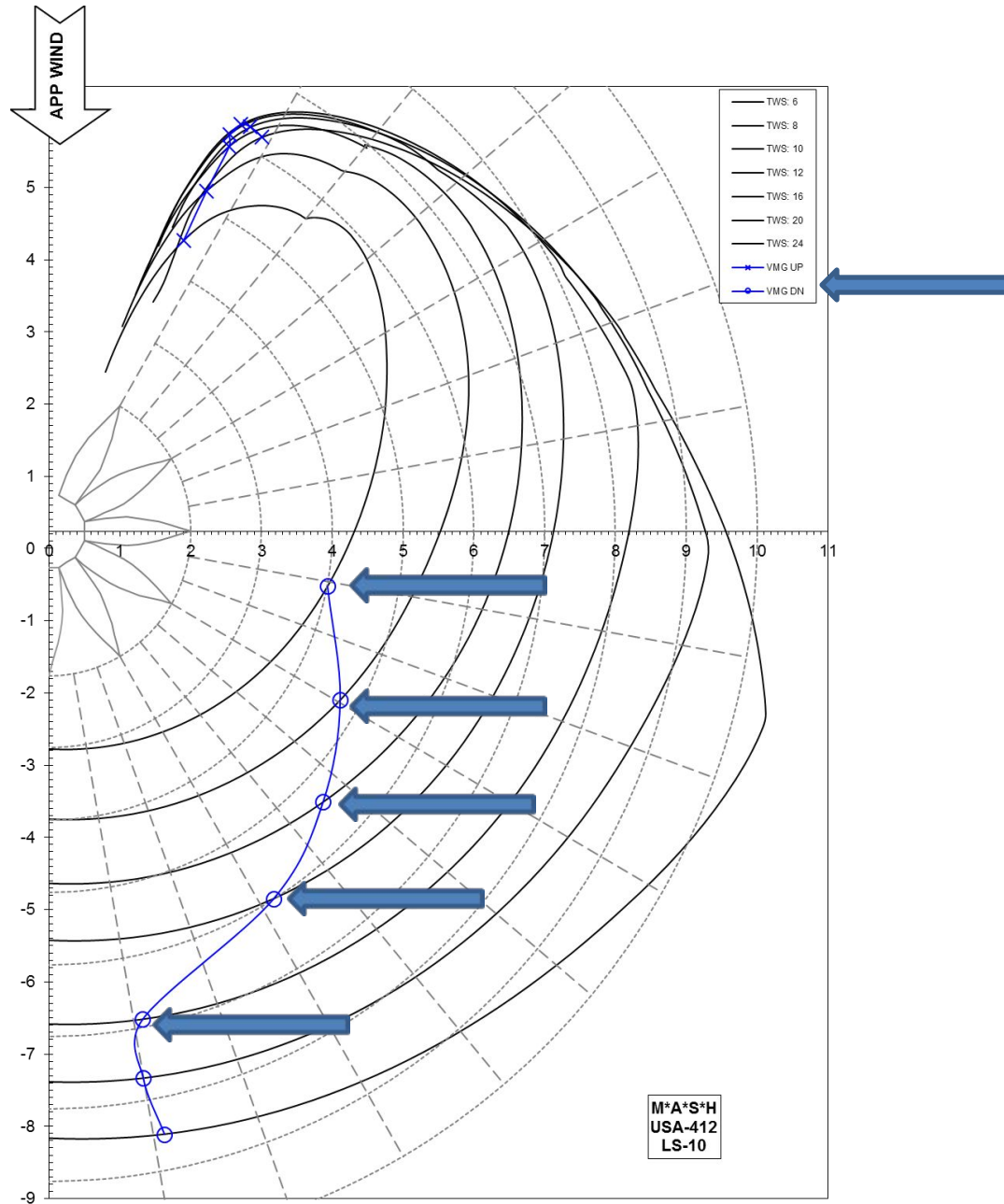
TWS: 6, 8, 10, 12, 14, 16, 20 kts  
Jib  
Symmetric Spinnaker



# AWA Polar Diagram



# AWA Polar Diagram



# Downwind Targets in a Chart

True Wind Speed  (kts)	<u>DOWNWIND VMG</u>			True Wind Angle  (deg)
	Boat Speed	App Wind Speed	App Wind Angle	
	(kts)	(kts)	(deg)	
<b>6</b>	<b>4.01</b>	<b>3.5</b>	<b>101.0</b>	<b>144.0</b>
<b>8</b>	<b>4.73</b>	<b>4.2</b>	<b>119.6</b>	<b>152.0</b>
<b>10</b>	<b>5.39</b>	<b>5.1</b>	<b>134.1</b>	<b>157.9</b>
<b>12</b>	<b>6.00</b>	<b>6.0</b>	<b>148.0</b>	<b>164.0</b>
<b>16</b>	<b>6.89</b>	<b>8.6</b>	<b>168.9</b>	<b>173.9</b>
<b>20</b>	<b>7.69</b>	<b>11.6</b>	<b>170.0</b>	<b>174.0</b>
<b>24</b>	<b>8.51</b>	<b>14.7</b>	<b>168.9</b>	<b>173.0</b>

# Target Boat Speeds

- Target boat speeds focus the effort of the crew on efficiently shifting gears, accelerating the boat, and getting to the target speed. They also help decelerate the boat when the wind drops.
- Accurate polars and target speeds can make the difference between knowing you will go faster in a puff and knowing precisely how much faster you will go in that puff.
- 33 Textor, Ken (1995). [\*The New Book of Sail Trim\*](#). Sheridan House, Inc. p. 228. [ISBN 0924486813](#).

# Downwind Targets in a Chart

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# Set up for the Downwind Leg

- What's the true wind speed (get this input in the upwind leg)
- What should be our target boat speed
- What should be our target apparent wind angle (the pole should be perpendicular!)
- OMG the breeze is not constant, what should we do!!
- Concentrate on taking advantage of the Puffs
- Adapt and win!! Change is the only constant, he/she who adapts quickest will win!!



# Communication

- The spin trimmer – helmsman communication is key
- Set up for the Polar target for the TWS
- Trimmer calls pressure or no
- If no pressure head up
- If over target speed head down – Puffs are Key
- Does the VMG on your GPS help?
- Chasing your tail

# How not to chase your tail

- Look behind you for dark water and anticipation for heading down
- Helmsman and trimmer must work in tandem with puff caller
- Constant communication on speed and sheet pressure

# Be Aware of How Others are Doing

- Watch how you are netting out against boats around you. “The best drivers can feel a little pressure on the helm when they start cookin’,” says Tom. “It’s kind of a vibration. Again the speedo is the key instrument, and the helmsman essentially lives and dies by it. Figure out what speed seems to net out well and then steer up or down to maintain that speed.”
- Jobson and Whidden, *Championship Tactics*, 1990, p. 276

# Error Hot or Error Low

- OK, we've seen this movie before
- But keeping on the target is easier said than done
- I know I will be on one side or the other
- Which side should I be on
  
- I'm glad you asked that question. . .

# 6 knots TWS

6.0	154.0	3.00	122.51	3.572	-3.210	0.4	1.0000	1.0000	1.2745	2	Sym Spin
6.0	153.0	3.03	120.27	3.610	-3.216	0.4	1.0000	1.0000	1.3259	2	Sym Spin
6.0	152.0	3.07	118.05	3.649	-3.222	0.5	1.0000	1.0000	1.3753	2	Sym Spin
6.0	151.0	3.11	115.85	3.689	-3.226	0.5	1.0000	1.0000	1.4227	2	Sym Spin
6.0	150.0	3.15	113.67	3.730	-3.230	0.5	1.0000	1.0000	1.4683	2	Sym Spin
6.0	149.0	3.19	111.50	3.773	-3.234	0.5	1.0000	1.0000	1.5122	2	Sym Spin
6.0	148.0	3.24	109.36	3.817	-3.237	0.6	1.0000	1.0000	1.5545	2	Sym Spin
6.0	147.0	3.29	107.23	3.862	-3.239	0.6	1.0000	1.0000	1.5953	2	Sym Spin
6.0	146.0	3.34	105.13	3.909	-3.241	0.6	1.0000	1.0000	1.6347	2	Sym Spin
6.0	145.0	3.40	103.04	3.957	-3.242	0.6	1.0000	1.0000	1.6727	2	Sym Spin
6.0	144.0	3.45	100.98	4.007	-3.242	0.7	1.0000	1.0000	1.7094	2	Sym Spin
6.0	143.0	3.51	98.95	4.059	-3.242	0.7	1.0000	1.0000	1.7449	2	Sym Spin
6.0	142.0	3.58	96.94	4.112	-3.240	0.8	1.0000	1.0000	1.7793	2	Sym Spin
6.0	141.0	3.64	94.95	4.167	-3.238	0.8	1.0000	1.0000	1.8125	2	Sym Spin
6.0	140.0	3.71	93.00	4.223	-3.235	0.8	1.0000	1.0000	1.8446	2	Sym Spin
6.0	139.0	3.78	91.08	4.280	-3.230	0.9	1.0000	1.0000	1.8755	2	Sym Spin
6.0	138.0	3.86	89.20	4.339	-3.224	0.9	1.0000	1.0000	1.9053	2	Sym Spin
6.0	137.0	3.94	87.36	4.399	-3.217	1.0	1.0000	1.0000	1.9339	2	Sym Spin
6.0	136.0	4.02	85.56	4.459	-3.208	1.0	1.0000	1.0000	1.9613	2	Sym Spin
6.0	135.0	4.10	83.80	4.520	-3.196	1.1	1.0000	1.0000	1.9874	2	Sym Spin
6.0	134.0	4.19	82.09	4.582	-3.183	1.1	1.0000	1.0000	2.0122	2	Sym Spin

# 6 knots TWS

- 4.01 knots Target Boat Speed
- 3.242 knots Target VMG
- $10^0$  too high – 3.183 knots VMG or 1.8% slower
- $10^0$  too low – 3.210 knots VMG or .9% slower
- So error is small but twice as much, so err low not high



# 8 knots TWS

8.0	162.0	3.80	141.35	4.342	-4.129	0.5	1.0000	1.0000	0.8056	2	Sym Spin
8.0	161.0	3.83	139.16	4.374	-4.136	0.5	1.0000	1.0000	0.8618	2	Sym Spin
8.0	160.0	3.85	136.96	4.408	-4.142	0.5	1.0000	1.0000	0.9179	2	Sym Spin
8.0	159.0	3.88	134.78	4.444	-4.149	0.5	1.0000	1.0000	0.9736	2	Sym Spin
8.0	158.0	3.91	132.60	4.481	-4.154	0.5	1.0000	1.0000	1.0288	2	Sym Spin
8.0	157.0	3.95	130.42	4.519	-4.160	0.6	1.0000	1.0000	1.0833	2	Sym Spin
8.0	156.0	3.98	128.25	4.559	-4.164	0.6	1.0000	1.0000	1.1370	2	Sym Spin
8.0	155.0	4.02	126.09	4.600	-4.169	0.6	1.0000	1.0000	1.1896	2	Sym Spin
8.0	154.0	4.06	123.94	4.642	-4.172	0.6	1.0000	1.0000	1.2409	2	Sym Spin
8.0	153.0	4.11	121.82	4.685	-4.174	0.7	1.0000	1.0000	1.2906	2	Sym Spin
8.0	152.0	4.16	119.71	4.728	-4.175	0.7	1.0000	1.0000	1.3384	2	Sym Spin
8.0	151.0	4.21	117.64	4.773	-4.174	0.7	1.0000	1.0000	1.3843	2	Sym Spin
8.0	150.0	4.26	115.59	4.817	-4.172	0.8	1.0000	1.0000	1.4282	2	Sym Spin
8.0	149.0	4.32	113.57	4.862	-4.168	0.8	1.0000	1.0000	1.4702	2	Sym Spin
8.0	148.0	4.38	111.59	4.908	-4.162	0.9	1.0000	1.0000	1.5105	2	Sym Spin
8.0	147.0	4.45	109.64	4.954	-4.155	0.9	1.0000	1.0000	1.5491	2	Sym Spin
8.0	146.0	4.51	107.72	5.001	-4.146	0.9	1.0000	1.0000	1.5861	2	Sym Spin
8.0	145.0	4.58	105.83	5.048	-4.135	1.0	1.0000	1.0000	1.6216	2	Sym Spin
8.0	144.0	4.66	103.98	5.095	-4.122	1.0	1.0000	1.0000	1.6558	2	Sym Spin
8.0	143.0	4.73	102.15	5.144	-4.108	1.1	1.0000	1.0000	1.6887	2	Sym Spin
8.0	142.0	4.81	100.35	5.194	-4.093	1.1	1.0000	1.0000	1.7205	2	Sym Spin

# 8 knots TWS

- 4.73 knots Target Boat Speed
- 4.175 knots Target VMG
- $10^0$  too high – 4.093 knots VMG or 2.0% slower
- $10^0$  too low – 4.129 knots VMG or 1.1 % slower
- So error is small but again twice as much, so err low not high

# 10 knots TWS

10.0	168.0	4.76	155.20	5.075	-4.965	0.5	1.0000	1.0000	0.4624	2	Sym Spin
10.0	167.0	4.78	153.11	5.100	-4.970	0.5	1.0000	1.0000	0.5117	2	Sym Spin
10.0	166.0	4.80	151.02	5.126	-4.974	0.5	1.0000	1.0000	0.5620	2	Sym Spin
10.0	165.0	4.82	148.94	5.154	-4.978	0.6	1.0000	1.0000	0.6133	2	Sym Spin
10.0	164.0	4.84	146.85	5.182	-4.982	0.6	1.0000	1.0000	0.6654	2	Sym Spin
10.0	163.0	4.87	144.76	5.213	-4.985	0.6	1.0000	1.0000	0.7182	2	Sym Spin
10.0	162.0	4.90	142.68	5.244	-4.987	0.6	1.0000	1.0000	0.7713	2	Sym Spin
10.0	161.0	4.93	140.61	5.277	-4.989	0.7	1.0000	1.0000	0.8246	2	Sym Spin
10.0	160.0	4.96	138.53	5.311	-4.991	0.7	1.0000	1.0000	0.8778	2	Sym Spin
10.0	159.0	5.00	136.47	5.347	-4.992	0.7	1.0000	1.0000	0.9307	2	Sym Spin
10.0	158.0	5.04	134.41	5.384	-4.992	0.8	1.0000	1.0000	0.9830	2	Sym Spin
10.0	157.0	5.08	132.36	5.423	-4.992	0.8	1.0000	1.0000	1.0349	2	Sym Spin
10.0	156.0	5.13	130.31	5.464	-4.991	0.8	1.0000	1.0000	1.0860	2	Sym Spin
10.0	155.0	5.17	128.27	5.506	-4.990	0.9	1.0000	1.0000	1.1365	2	Sym Spin
10.0	154.0	5.22	126.24	5.550	-4.988	0.9	1.0000	1.0000	1.1859	2	Sym Spin
10.0	153.0	5.28	124.23	5.595	-4.985	1.0	1.0000	1.0000	1.2342	2	Sym Spin
10.0	152.0	5.33	122.24	5.640	-4.980	1.0	1.0000	1.0000	1.2809	2	Sym Spin
10.0	151.0	5.39	120.27	5.687	-4.974	1.0	1.0000	1.0000	1.3260	2	Sym Spin
10.0	150.0	5.46	118.32	5.734	-4.966	1.1	1.0000	1.0000	1.3694	2	Sym Spin
10.0	149.0	5.53	116.40	5.781	-4.955	1.1	1.0000	1.0000	1.4110	2	Sym Spin
10.0	148.0	5.60	114.51	5.828	-4.942	1.1	1.0000	1.0000	1.4508	2	Sym Spin

# 10 knots TWS

- 5.39 knots Target Boat Speed
- 4.992 knots Target VMG
- $10^0$  too high – 4.942 knots VMG or 1.0% slower
- $10^0$  too low – 4.965 knots VMG or .5 % slower
- So error is small but again twice as much, so err low not high

# 12 knots TWS

12.0	174.0	5.85	168.10	5.749	-5.717	0.4	1.0000	1.0000	0.1779	2	Sym Spin
12.0	173.0	5.85	166.10	5.768	-5.725	0.4	1.0000	1.0000	0.2199	2	Sym Spin
12.0	172.0	5.86	164.09	5.789	-5.732	0.5	1.0000	1.0000	0.2628	2	Sym Spin
12.0	171.0	5.86	162.08	5.811	-5.739	0.5	1.0000	1.0000	0.3065	2	Sym Spin
12.0	170.0	5.88	160.07	5.834	-5.745	0.6	1.0000	1.0000	0.3511	2	Sym Spin
12.0	169.0	5.89	158.06	5.858	-5.751	0.6	1.0000	1.0000	0.3965	2	Sym Spin
12.0	168.0	5.91	156.04	5.884	-5.755	0.6	1.0000	1.0000	0.4428	2	Sym Spin
12.0	167.0	5.92	154.03	5.911	-5.759	0.7	1.0000	1.0000	0.4899	2	Sym Spin
12.0	166.0	5.95	152.02	5.938	-5.762	0.7	1.0000	1.0000	0.5379	2	Sym Spin
12.0	165.0	5.97	150.01	5.967	-5.763	0.7	1.0000	1.0000	0.5867	2	Sym Spin
12.0	164.0	6.00	148.01	5.996	-5.764	0.8	1.0000	1.0000	0.6363	2	Sym Spin
12.0	163.0	6.03	146.02	6.027	-5.763	0.8	1.0000	1.0000	0.6864	2	Sym Spin
12.0	162.0	6.07	144.03	6.058	-5.761	0.9	1.0000	1.0000	0.7369	2	Sym Spin
12.0	161.0	6.11	142.05	6.089	-5.758	0.9	1.0000	1.0000	0.7875	2	Sym Spin
12.0	160.0	6.15	140.09	6.122	-5.752	0.9	1.0000	1.0000	0.8379	2	Sym Spin
12.0	159.0	6.19	138.14	6.154	-5.745	1.0	1.0000	1.0000	0.8879	2	Sym Spin
12.0	158.0	6.24	136.21	6.187	-5.736	1.0	1.0000	1.0000	0.9374	2	Sym Spin
12.0	157.0	6.30	134.29	6.220	-5.725	1.1	1.0000	1.0000	0.9860	2	Sym Spin
12.0	156.0	6.35	132.40	6.253	-5.712	1.1	1.0000	1.0000	1.0338	2	Sym Spin
12.0	155.0	6.41	130.53	6.286	-5.697	1.2	1.0000	1.0000	1.0807	2	Sym Spin
12.0	154.0	6.48	128.67	6.319	-5.680	1.2	1.0000	1.0000	1.1266	2	Sym Spin

# 12 knots TWS

- 6.00 knots Target Boat Speed
- 5.764 knots Target VMG
- $10^0$  too high – 5.680 knots VMG or 1.5% slower
- $10^0$  too low – 5.717 knots VMG or .8 % slower
- So error is small but almost twice, so err low not high



# Err on the side of too Low

- These are theoretical numbers and as you can see are small – 1% is 36 seconds in an hour long race.
- Probably more important is the sea state
- Usually sail a different angle on each gybe
- Sometimes rough sea conditions will make the sails dance around so much the “effective sail area” goes way down. The ‘cliff’ moves to the left. . . The fastest way to the mark may be directly downwind, even in light air!
- Ockam Instruments, 2014
- Other times it is more important to keep the boat moving so head up and get to a corner

# Downwind Targets in a Chart

True Wind Speed  (kts)	<u>DOWNWIND VMG</u>			True Wind Angle  (deg)
	Boat Speed	App Wind Speed	App Wind Angle	
	(kts)	(kts)	(deg)	
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<b>10</b>	<b>5.39</b>	<b>5.1</b>	<b>134.1</b>	<b>157.9</b>
<b>12</b>	<b>6.00</b>	<b>6.0</b>	<b>148.0</b>	<b>164.0</b>
<b>16</b>	<b>6.89</b>	<b>8.6</b>	<b>168.9</b>	<b>173.9</b>
<b>20</b>	<b>7.69</b>	<b>11.6</b>	<b>170.0</b>	<b>174.0</b>
<b>24</b>	<b>8.51</b>	<b>14.7</b>	<b>168.9</b>	<b>173.0</b>

# Summary

- Know the Downwind Cliff
- Appreciate why it is an anomaly
- Post your Targets on your bulkhead
- Try to pick and maintain a Target Boat Speed
- Feel your boat and monitor your progress with respect to the boats near you
- Try to anticipate the puffs and work down
- Adapt!
- Be Happy – Enjoy the View of Spinnakers Behind

# Happy



- **QUESTIONS**