Ascents from 200 ft (61m) Dives on Trimix 18/45

Comparison of V-Planner VPM-B to GAP RGBM and GF Deco Tables

•This compilation demonstrates that VPM-B is linearly correlated to RGBM, and is dissimilar to GF decompression for an array of dive profiles.

•Analytical dive planning is also discussed, with consideration of lost gas scenarios, rules for VPM-B deco-on-the-fly, and gas consumption vs. bottom times and deco gas sets.

Organization

Notations and Conventions

ALL CONLUSIONS and GENERALIZATIONS PERTAIN ONLY to the SPECIFIC DEPTHS, GAS MIXTURES, and PROGRAM SETTINGS CONSIDERED in this DOCUMENT

Profiles

•12 profiles of 200 ft on Trimix 18/45 back gas, with bottom time ranging from 10-120 min are modeled, with deco using back gas and standard mixes: Nitrox 50/50 and O_2.
•Total of 144 VPM-B models = 12-profiles x 3-conservatisms x 4 deco gas combinations (full set; lost O_2; lost 50/50; lost 50/50 and O_2).
•Correlations of RGBM and GF to 36 VPM-B models = 12-profiles x 3 different conservatism settings (pages 8-12, 18-22, 28-32).
•All ascents at 33 ft/min. No breaks included from O_2 Exposure (I do 10-15 min on O2 / 3-5 min on back gas). All descents on back gas at 100 ft/min.

Plots

•Gas mixtures denoted as percents in braces: {%O_2, %He, %N_2}
    •3mix 18/45 is then: {18,45,37}
•Three types of plots are shown that correlate VPM-B to RGBM and GF:
    •RGBM and GF vs. VPM Total Ascent Times (pages: 12, 22, 32)
    •Overlaid stair-step profiles (pages: 8, 10, 18, 20, 28, 30)
    •RGBM, and GF Stop-times vs. VPM-B stop-times (pages: 9, 11, 19, 21, 29, 31)
•Diagonal lines in plots are *NOT* fitted correlations –they are just indications of 1:1 correlation to guide your eyes.
    •Points that lie above the lines denote longer GF and RGBM times, while points below the lines indicate longer VPM-B times.
•I use Imperial American units and conventions. Soon, you may too if 'W' has his way! cf == cubic feet (volume).1 cf = 28.23 liters. In the USA, tank capacities are discussed in terms of the volume of gas that is contained at the maximum rated pressure. psi == pounds per square inch (pressure). 1foot = 0.3048 meters.

V-Planner and GAP Software Settings

•Ascents calculated by GAP RGBM v2.1.3 (Aug, 2003 Edition) and V-Planner (VPM-B) v3.22.
•VPM conservatisms are denoted: Nominal as VPM-B (N), Level 2 as VPM-B (2), and Level 4 as VPM-B (4).
•RGBM and GF run at nominal GAP conservatisms. VPM-B run at nominal (N), (2), and (4) conservatisms.

Dive Planning Example:
200 ft for 20-min + Ascent

Objective

- I used this data set to plan a recent dive on the Ring Reef off of Catalina Island's ship rock. See: http://www.decompression.org/maiken/IsthmusDeep.htm

VPM-B Deco

- Plan deco for a dive that can be sustained under most lost-gas scenarios.
- Have an analytically based plan for deco-on-the-fly (see pages 6 and 38).

VPM-B(2) Deco-on-the-Fly for 20-min, 200ft Dive on 18/45 + 50/50 + O_2

- Rules are simple, approximate, and specific to the depth and gas mixtures.
- To be used in case diving operations depart from plan.
- Units are imperial American.

1. Ascend at 33 ft/min to 2-Atm shallower than bottom depth (=130 ft for 200ft dive).
2. Total Ascent Time = (Depth[feet]/100) x Bottom Time (==200/100 x 20 = 40 min for 20 min BT).
3. Time at 30 and 20ft = ½ Bottom Time (=10 min). Spend more time at 20 than 30.
4. Time at 10ft = ½ Bottom Time (=10 min).
5. Pull 10 ft stop near 20 ft, with breaks. Pad 20-10 ft stop times if possible.
6. For deep and intermediate stops, equally distribute the difference between TAT (40 min) and time at 30-10ft (20 min) on stops from first-stop @ 130 ft to 40ft stop (= 2-min per stop).
7. Rule 5 is ok as it stands, but better to shape the curve by doing only 1 min @ 130, 120, 110, and then, adding the difference in time to the 60, 50, 40 stops.

CONTIGENCIES

1. Lost O_2 increases TAT to 3x bottom time; time at 20+30ft = time at 10ft = bottom time.
2. Lost 50-50 increases TAT to 4x bottom time; time at 20+30ft = time at 10ft = bottom time.
3. Lost 50-50 an O_2 increases TAT to 5 x bottom time. Time at 10ft = 2x bottom time. Time at 20+30ft = 1.5x bottom time. Do not pull stops at deeper levels.

- To summarize, VPM-B(2) deco-on-the-fly for 20-min at 200-feet is, in {depth[feet], time[min]}:
  {{130,1}, {120,1}, {110,1}, {100,2}, {90,2}, {80,2}, {70,2}, {60,3}, {50,3}, {40,3}, {30,4}, {20,6}, {10,10}}.

Gas

My tanks, starting pressures, and mixes.

2xPST-104cf at 3000 psi Trimix 18/45 (~ 220 cf / 6210 liters of gas -real gas law-)
Al-80cf at 2000 psi Nx 50/50 (=53 cf / 1496 liters of gas)
Al-30cf at 2800 psi Oxygen (=28 cf / 790 liters of gas)

Plan: Maximum 20-min dive allows completion of deco on any set of gases (page 38).

Discussion of Correlation Plots for VPM-B to RGBM and GF Total Ascent Times (TATs)

VPM-B TATs Correlate Closely to RGBM –though Not to GF

General Notes

•All data include time to 1st stop at ascent rate of 33 ft/min.

•TATs are closely related to comparative surfacing gradients for VPM-B, RGBM, and GF because all three ascent methods employ similar stage depths. Therefore, roughly speaking, a longer TAT implies a more conservative schedule.

RGBM vs. VPM-B (pages 12, 22, 32 --upper graph)

•VPM-B(2) is nearly 1:1 correlated with RGBM –both models yield the same ascent times for a wide range of dive times. VPM-B(N) is linearly correlated with progressively shorter ascent times than RGBM for increasing dive times; VPM-B(4) is linearly correlated with progressively longer ascent times than RGBM.

GF vs. VPM-B (pages 12, 22, 32 -- lower graph)

•VPM-B is not linearly correlated to GF. For 'short' dives, of 10-30 min, VPM-B(4) always has longer TATs than GF.

•THIS PROPOSITION IS BEING IMPLICITLY TESTED BY V-PLANNER: Bühlmann doesn't credit for deep stops –so inclusion of deep stops in GF-modifications of algorithms based on Bühlmann a/b s *may* lead to too much conservatism. VPM-B credits deep stops. Therefore, VPM-B TATs are shorter than GF TATs.

Discussion of Correlation Plots of VPM-B to RGBM and GF Stop Times

VPM-B Stop Times Correlate Nearly 1:1 to RGBM –but Diverge from GF

General Notes

•The plots on pages 9, 11, 19, 21, 29, and 31 directly compare stop time vs. stop time for two different deco methods.They avoid the offsets that occur on the conventional stair-step depth vs. run-time plots of the same data, which are shown on pages 8, 10, 18, 20, 28, and 30.

•Data points are plots of the (x,y) pair: (VPM-B stop time, RGBM/GF stop time) for each decompression stop. Individual stop depths are not indicated, but generally, the longest stops correspond to the shallowest stops for each gas mixture. For O_2 deco, the 20 and 10 ft stops are shown as green-colored points. For 50/50 the 70-30 ft stops are shown as blue-colored points. Stops on back gas are shown as black-colored points. For the deepest stops, more than one point will often plot on top of another point.

RGBM vs. VPM-B (pages 9, 19, 29)

•VPM-B(N) stops on back gas are shallower and minutes shorter than RGBM. Stops on 50-50 and O_2 are comparable to RGBM. Generally, VPM-B(N) is more aggressive than RGBM (page 9).

•VPM-B(2) initial (deepest) stops on back gas are shallower and about a minute shorter than RGBM. VPM-B(2) stops on 50-50 are the same or longer than RGBM. Stops on O_2 are the same or longer than RGBM (page 19). Considering that VPM-B(2) and RGBM have identical TATs (page 12), we can summarize by noting that VPM-B(2) replaces the RGBM's low-O_2 window stops with high-O_2 window stops, and that VPM-B(2) is very similar to RGBM.

•VPM-B(4) starts stops at about the same depth as RGBM, but VPM-B (4) has much longer stops on 50-50 and O_2 (page 29).Generally, VPM-B(4) is much more conservative than RGBM (page 29).

GF vs. VPM-B (pages 11, 21, 31)

•GF and VPM-B stop times are correlated (though not linearly), with increasing divergence with increasing bottom times. In contrast to RGBM's nearly 1:1 linear correlation to VPM-B for all dives, GF profiles approach 2:1 differences in shallow stop times. This translates to hours of less predicted decompression time on VPM-B compared to GF.

Discussion of Plots of VPM-B Stop Times vs. Bottom Times

See pages 13-16, 23-26, 33-36

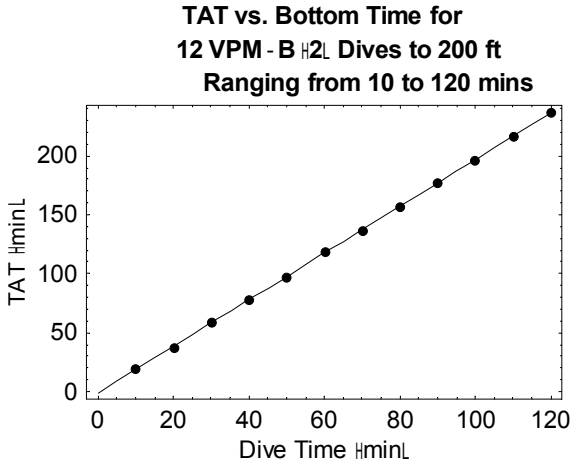
•TATs and groups of stop times (e.g. times at 10+20 ft) are linearly correlated to dive times. This translates to simple rules that relate stop times to bottom times. We can use these relationships to specify analytically-based procedures for VPM-B deco-on-the-fly.

•CAUTION: remember that the rules described in these slides are special cases that only relate to 200 ft dives on 3-mix 18/45.

•Nonetheless, linear relations can be used to describe just about every VPM-B dive scenario, and a general method will be described in forthcoming publications. This special case illustrates a framework that you can use for dive planning, and as a critical basis to discuss popular (though often ill-defined) concepts like: "deco-on-the-fly," or "the-shapes-of-the-deco-curves."

•For example, look at the upper left-hand plot on page 23, for Total Ascent Time (TAT) vs. Bottom Time for VPM-B (2). The graph is reproduced below, with an overlaid plot of a linear fit to the 12 data points.

•This linear fit is the analytical basis for Rule 2 for VPM-B deco on the fly, discussed on page 3. Rules number 3 and 4 were also based on easy-to-remember approximations of fits to the data for shallow stops plotted on page 23.



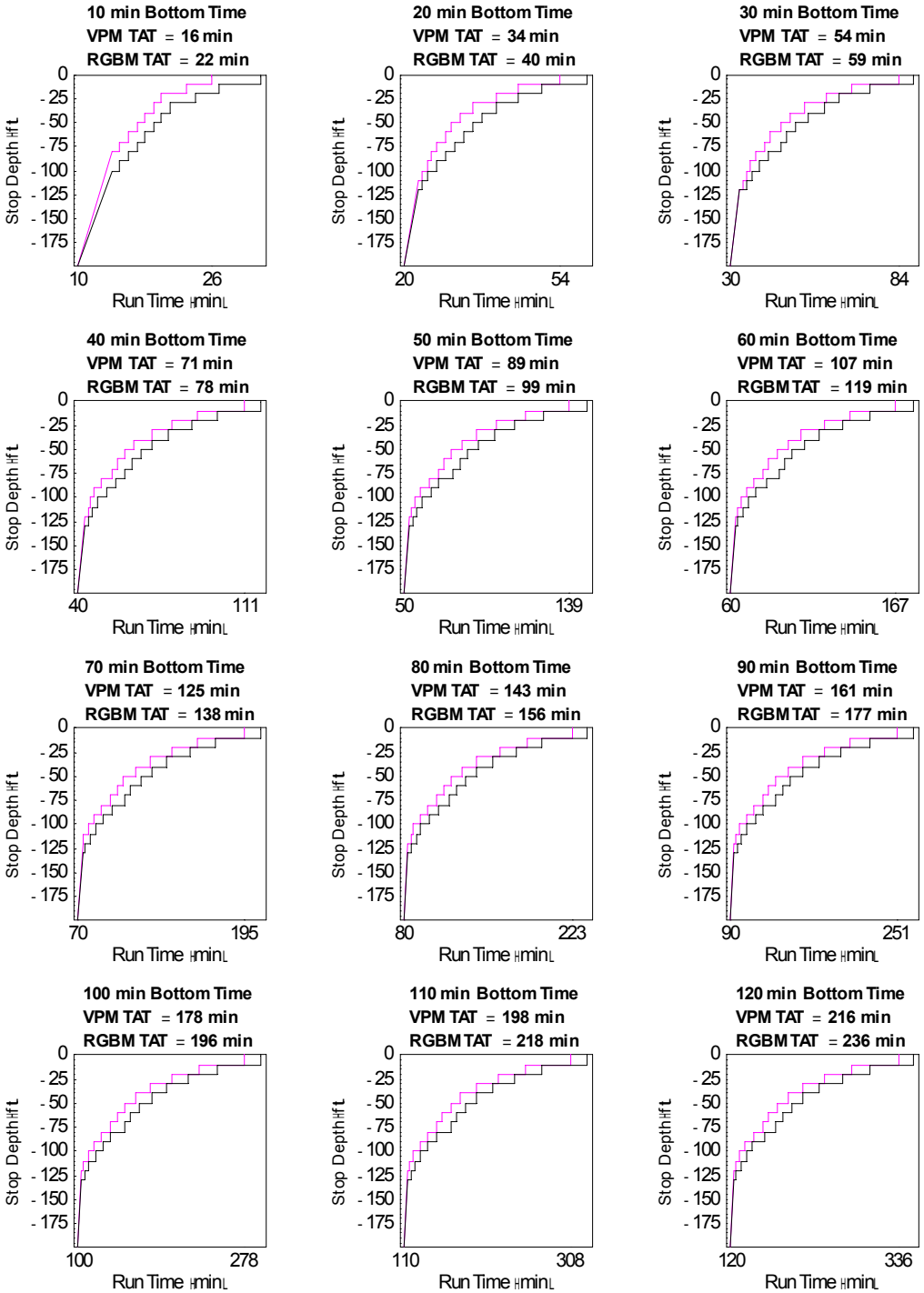
Points calculated by V-Planner for Total Ascent Time vs. bottom time for dives on 18/45 with 50-50 and O_2 Deco. The linear fit is very nearly: TAT = 2 x Bottom Time.

SECTION 1

Ascents from Dives at 200 ft for 10-120 min
VPM-B Conservatism Setting (N)

12 VPM-B profiles compared to RGBM and GF using full gas sets (pps. 8-12)
48 VPM-B ascents with various gases summarized (pps. 13-16)

Comparison of RGBM and VPM-B (NL) Ascents for Array of 200 ft Dives on Back Gas (O2, He, N2) = (18, 45, 37) Deco on (18, 45, 37), (50, 0, 50), and (100, 0, 0)



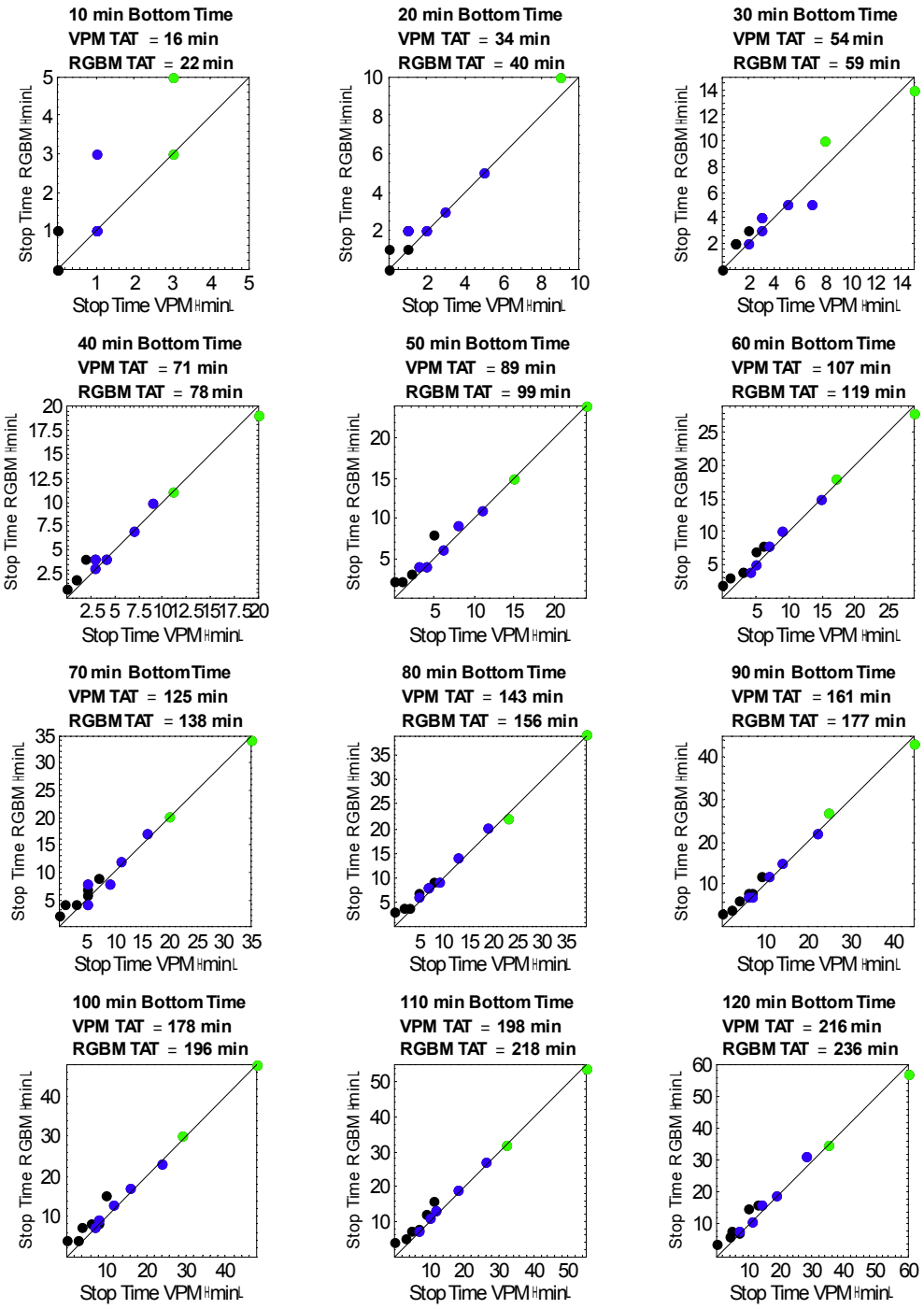
LEGEND
Dive Profiles

VPM-B
RGBM

Eric Maiken, 2003

Limited Distribution

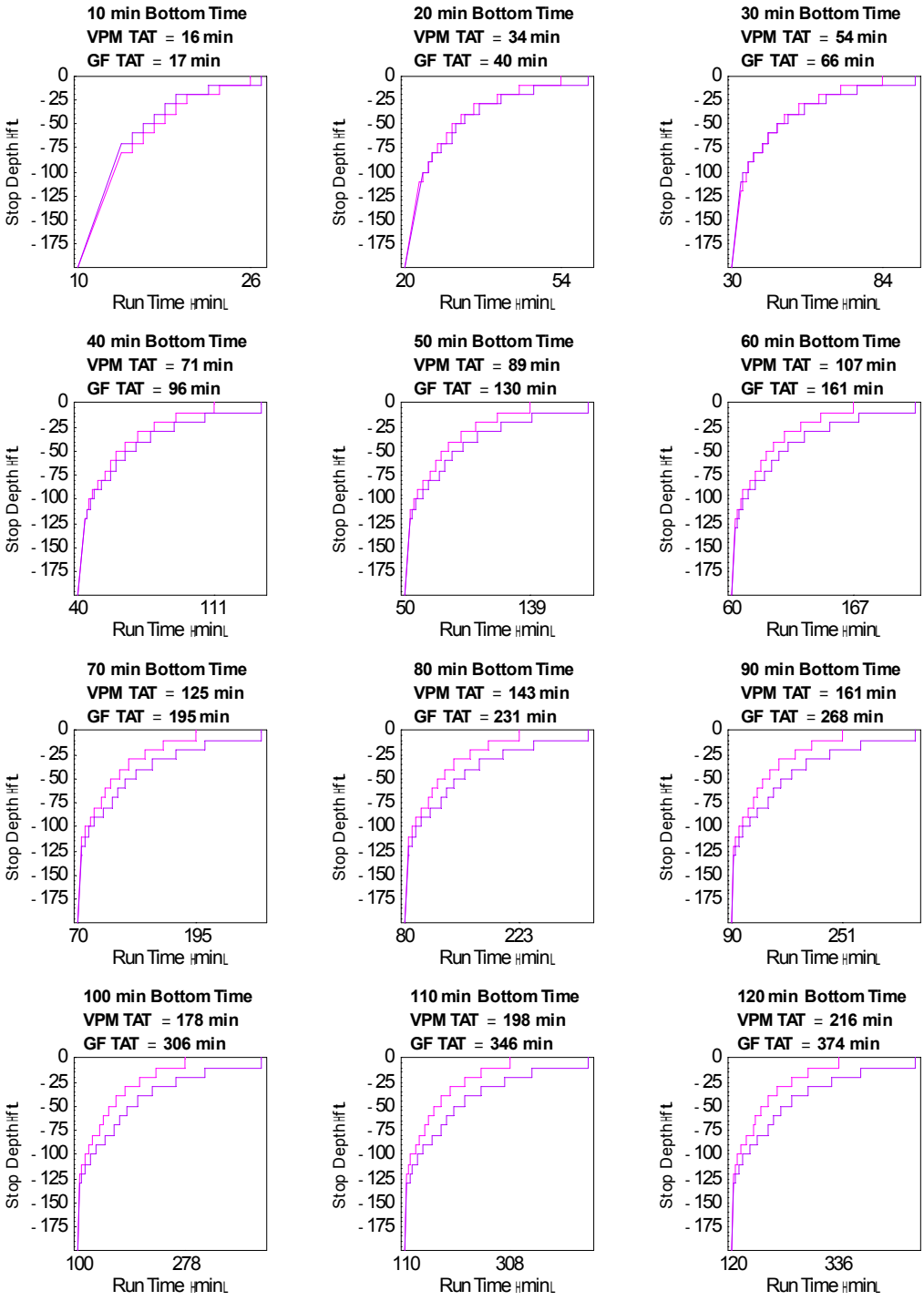
Correlation of RGBM to VPM-B (N) Stop Times for Array of 200 ft Dives on Back Gas {O_2, He, N_2} = {18, 45, 37} Deco on {18, 45, 37}, {50, 0, 50}, and {100, 0, 0}



LEGEND
Deco Gases
O_2, He, N_2
100, 0, 0
50, 0, 50

Eric Maiken, 2003 Limited Distribution

Comparison of GF and VPM-B (NL) Ascents for Array of 200 ft Dives on Back Gas (O2, He, N2<) = (18, 45, 37<) Deco on (18, 45, 37<, (50, 0, 50<, and (100, 0, 0<



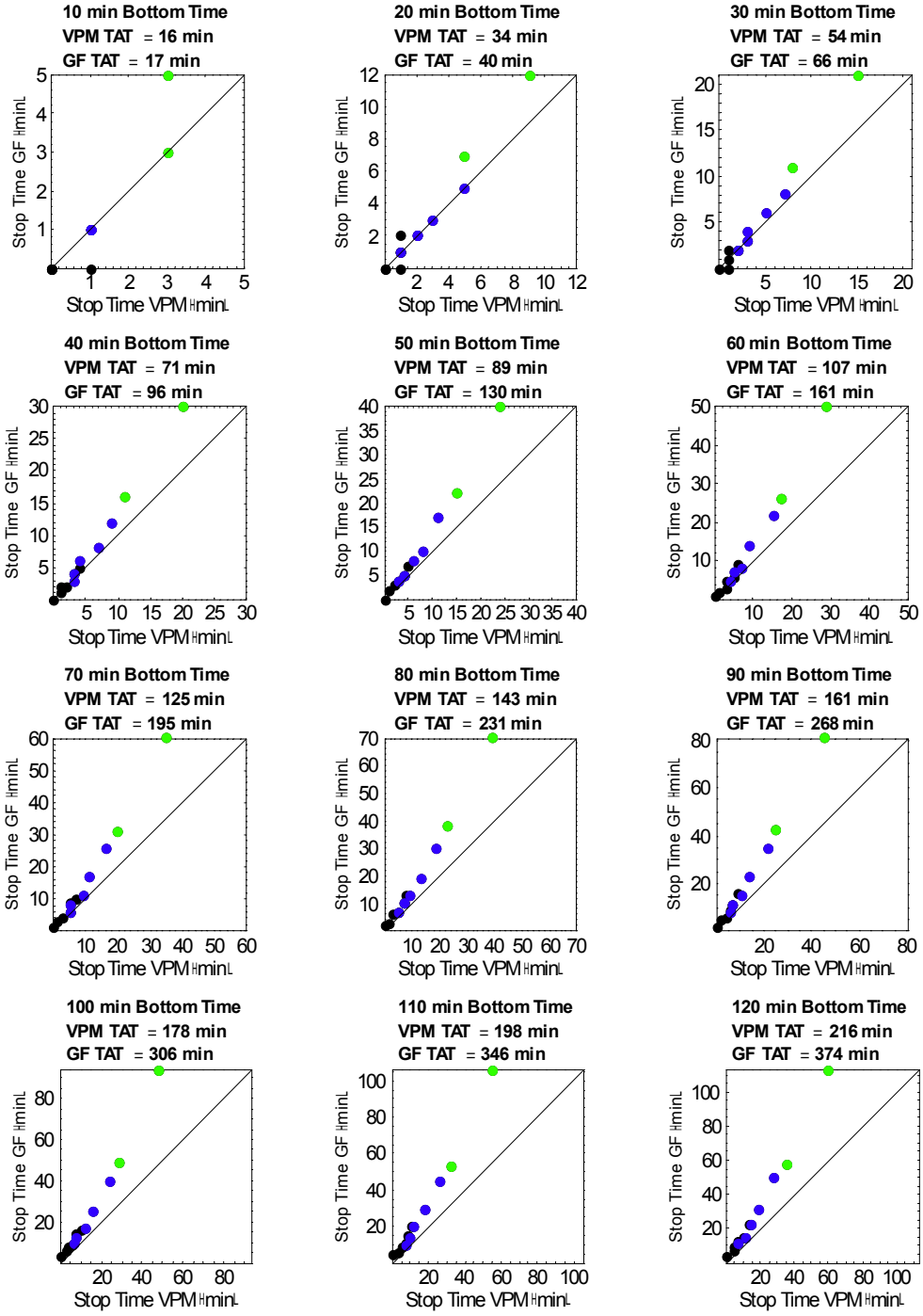
LEGEND
Dive Profiles

VPM-B
GF

Eric Maiken, 2003

Limited Distribution

Correlation of GF to VPM-B (N) Stop Times for Array of 200 ft Dives on Back Gas {O_2, He, N_2} = {18, 45, 37} Deco on {18, 45, 37}, {50, 0, 50}, and {100, 0, 0}

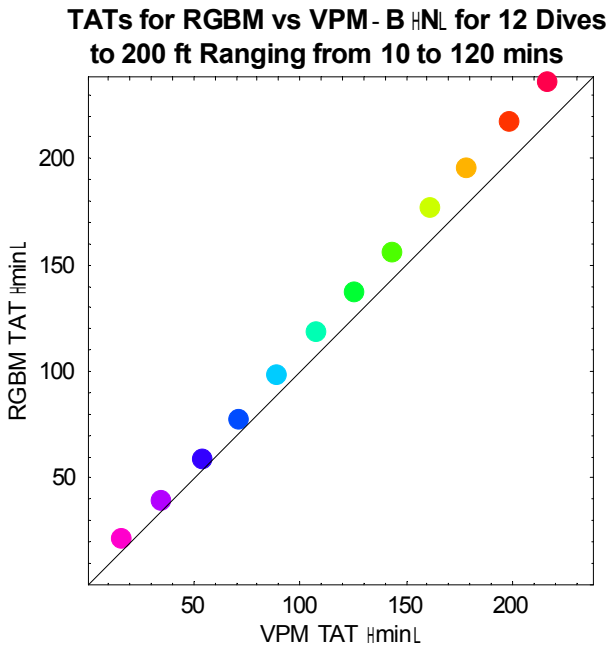


LEGEND
Deco Gases
O_2, He, N_2
100, 0, 0
50, 0, 50

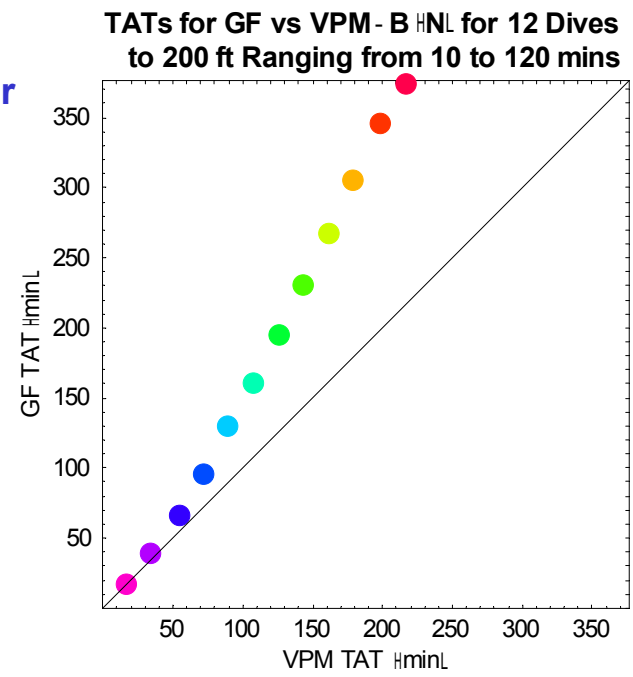
Eric Maiken, 2003 Limited Distribution

Correlation of VPM-B(N) TATs to RGBM and GF TATs for 200 ft Dives

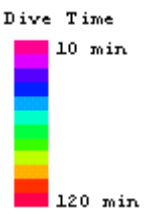
RGBM vs. VPM-B



Gradient Factor vs. VPM-B

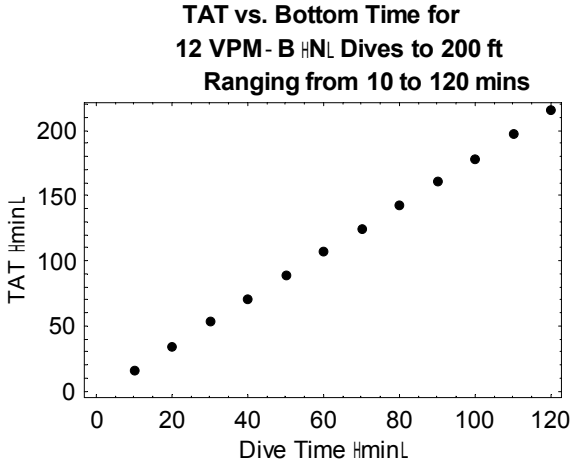


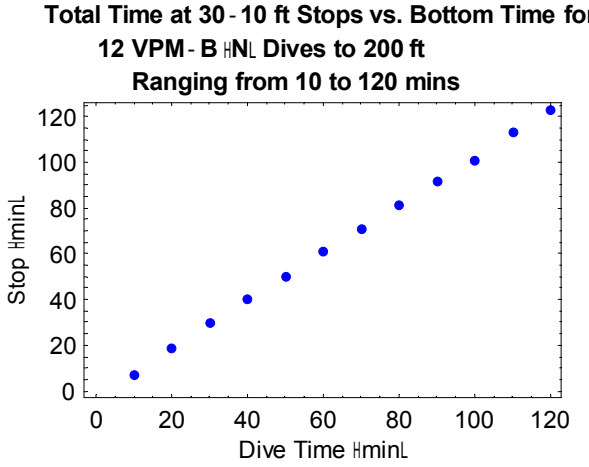
Legend

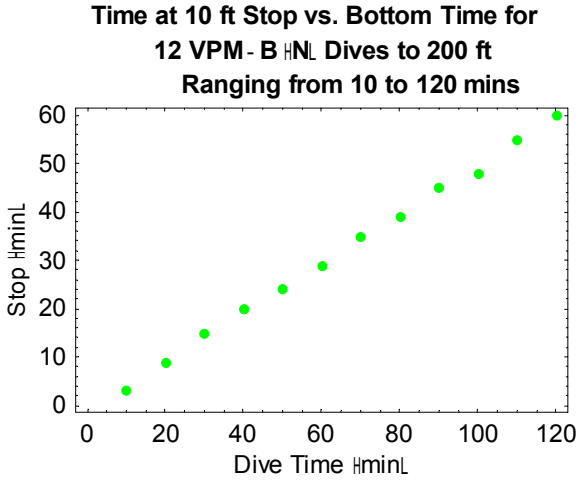


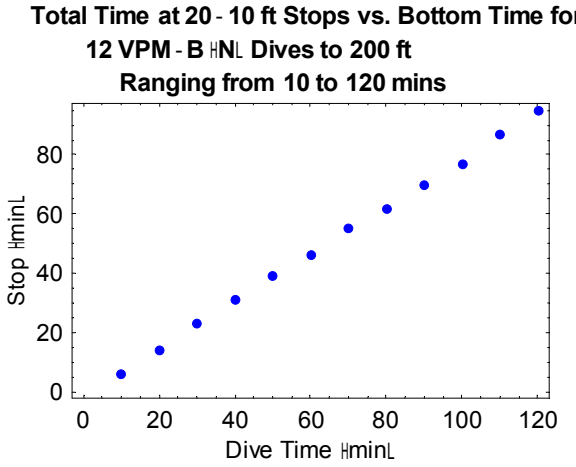
Stop Times vs. Bottom Times VPM-B Conservatism (N)

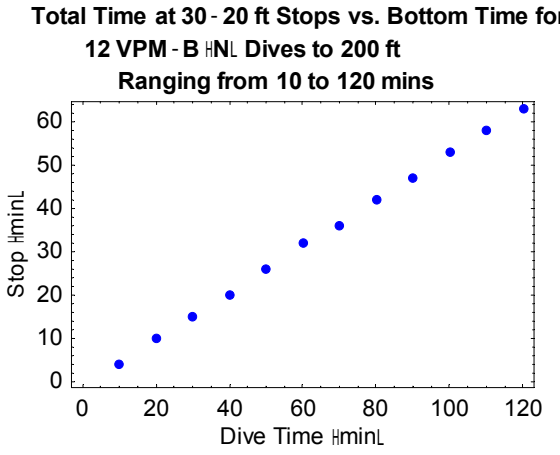
3 Deco Gases: 3mix 18/45,Nx50/50, O_2





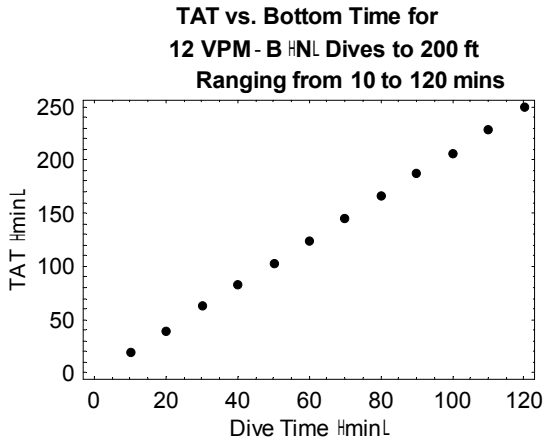


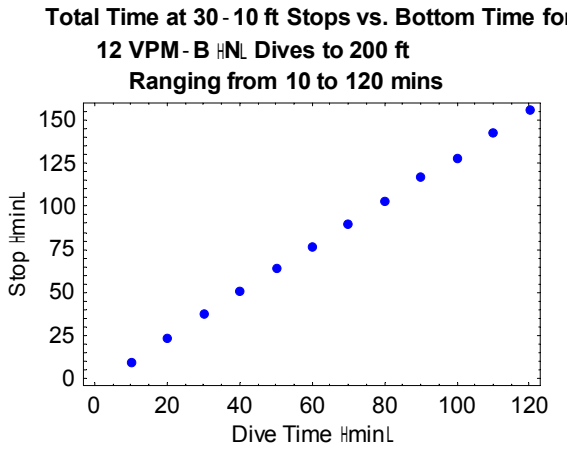


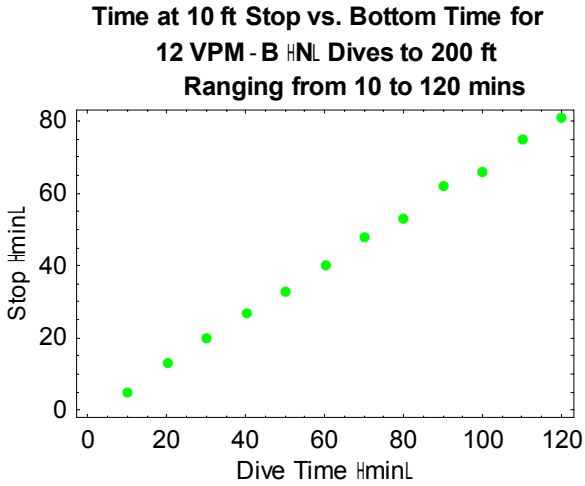


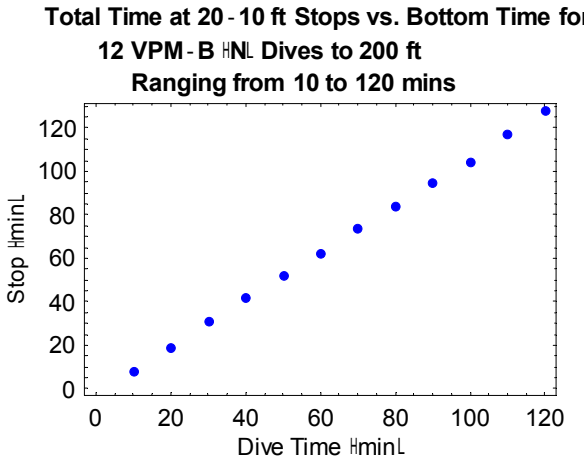
Stop Times vs. Bottom Times VPM-B(N) Lost O_2

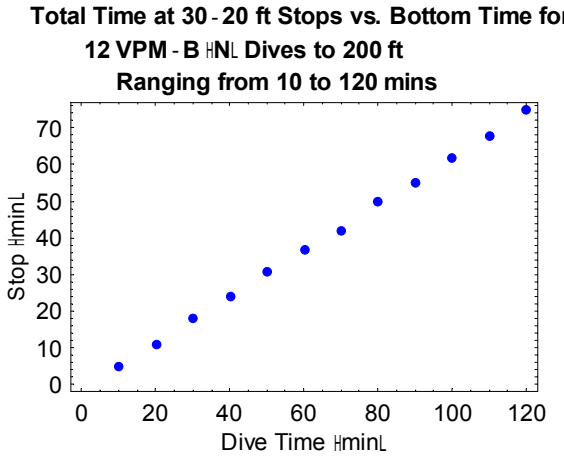
2 Deco Gases: 3mix 18/45,Nx50/50





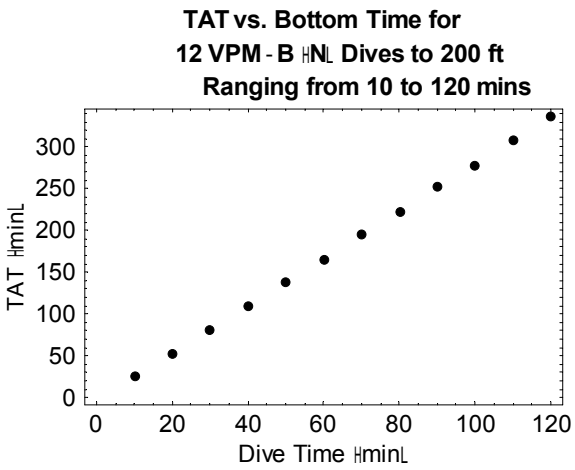


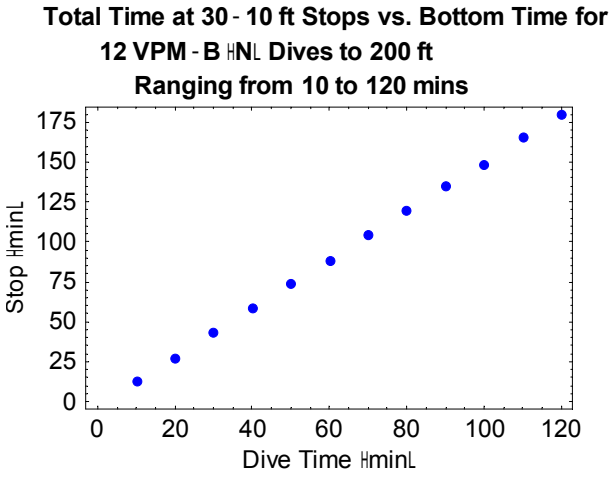


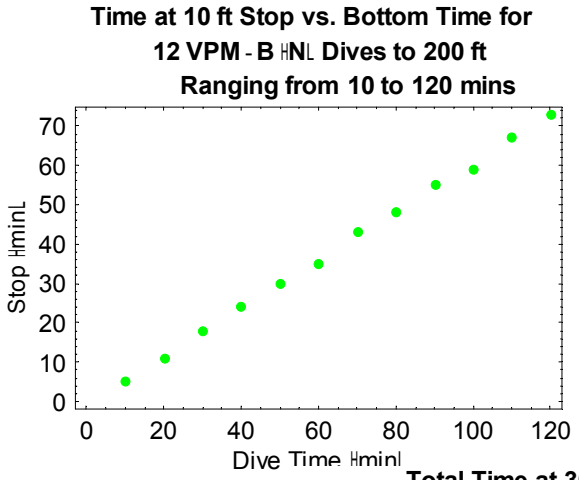


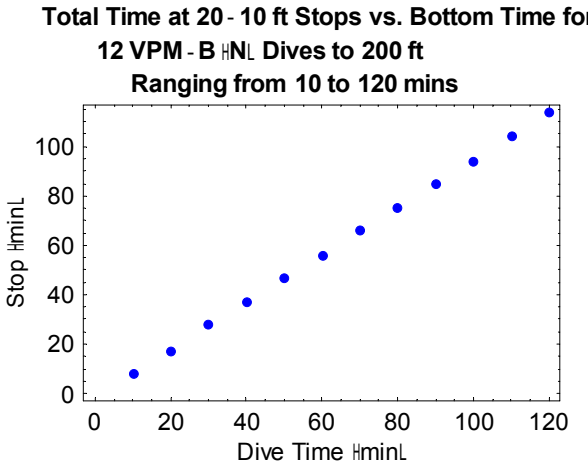
Stop Times vs. Bottom Times VPM-B(N) Lost 50-50

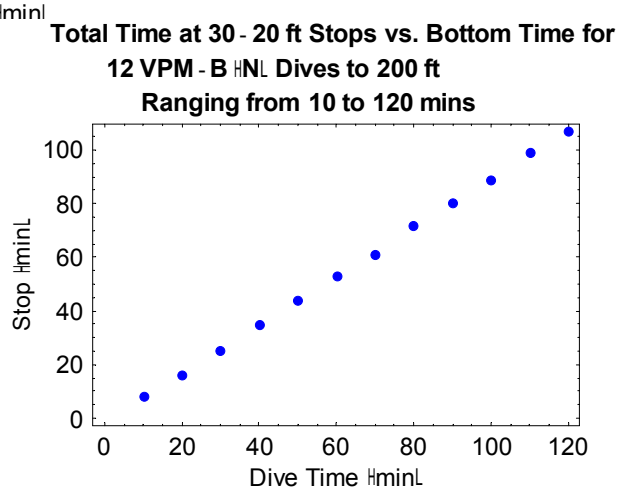
2 Deco Gases: 3mix 18/45, O_2





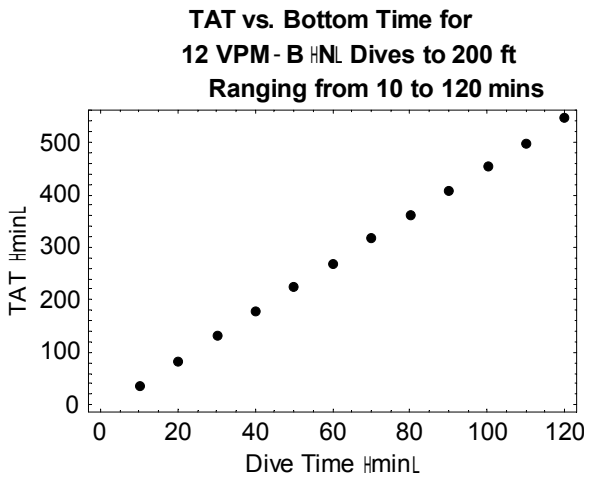


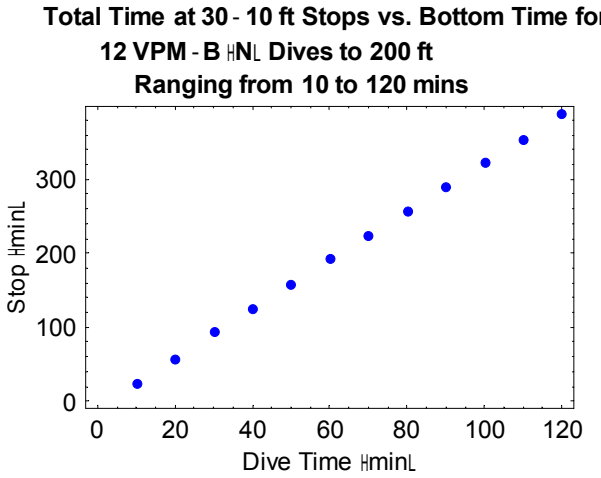


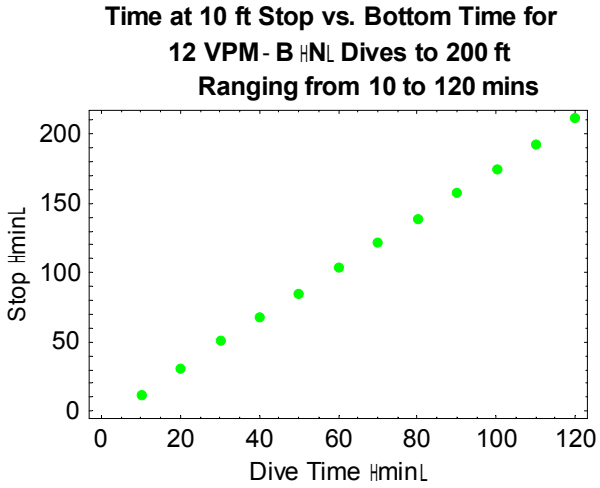


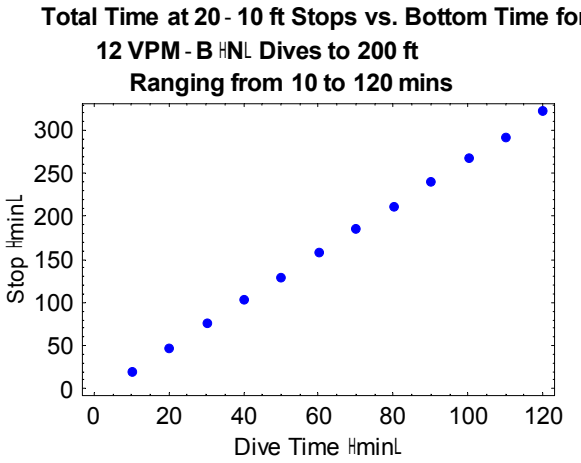
Stop Times vs. Bottom Times VPM-B(N) Lost 50-50 and O_2

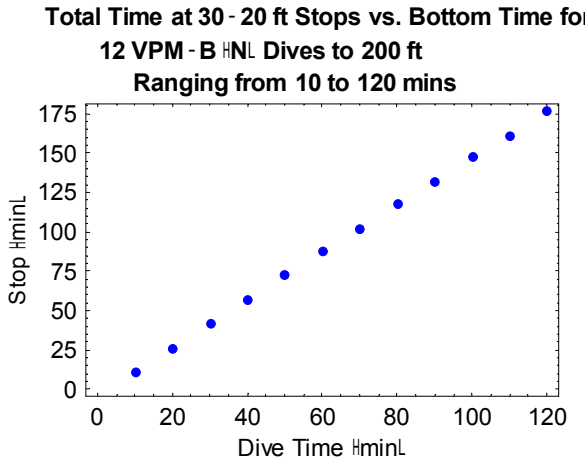
1 Deco Gas: 3mix 18/45









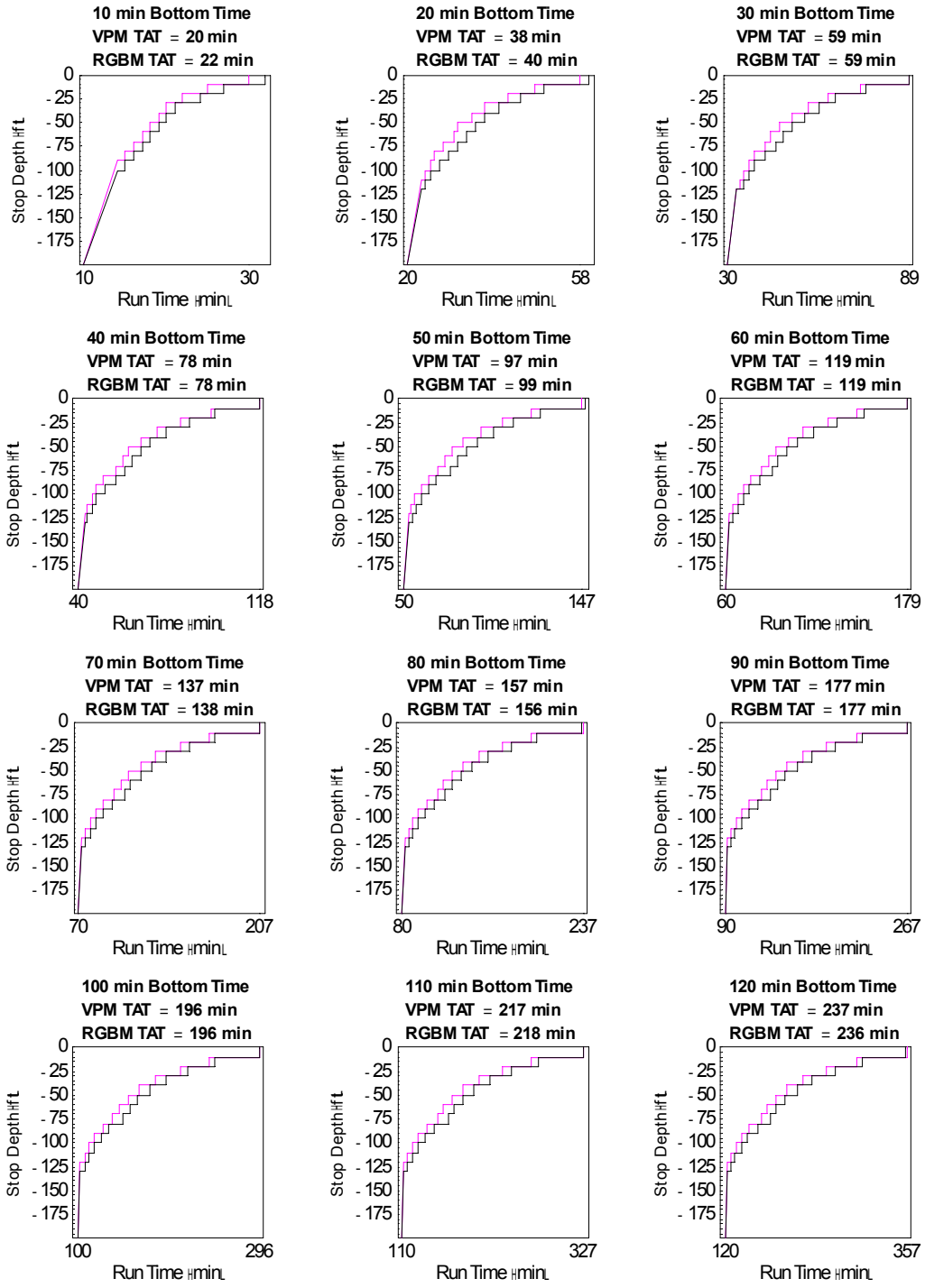


SECTION 2

Ascents from Dives at 200 ft for 10-120 min
VPM-B Conservatism Setting (2)

12 VPM-B profiles compared to RGBM and GF using full gas sets (pps. 18-22)
48 VPM-B ascents with various gases summarized (pps. 23-26)

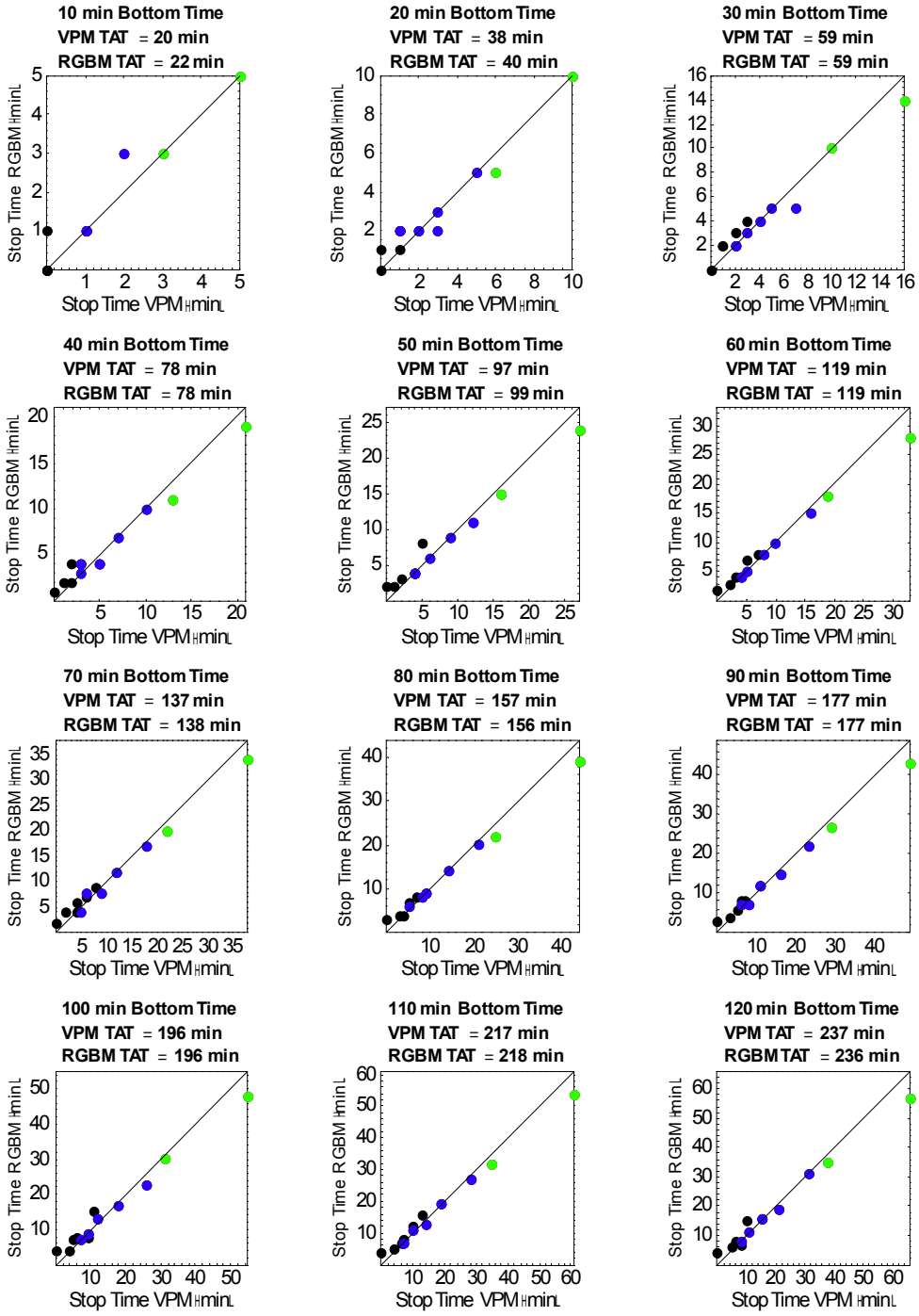
Comparison of RGBM and VPM-B (2) Ascents for Array of 200 ft Dives on Back Gas (O2, He, N2) = (18, 45, 37) Deco on (18, 45, 37), (50, 0, 50), and (100, 0, 0)



LEGEND
Dive Profiles

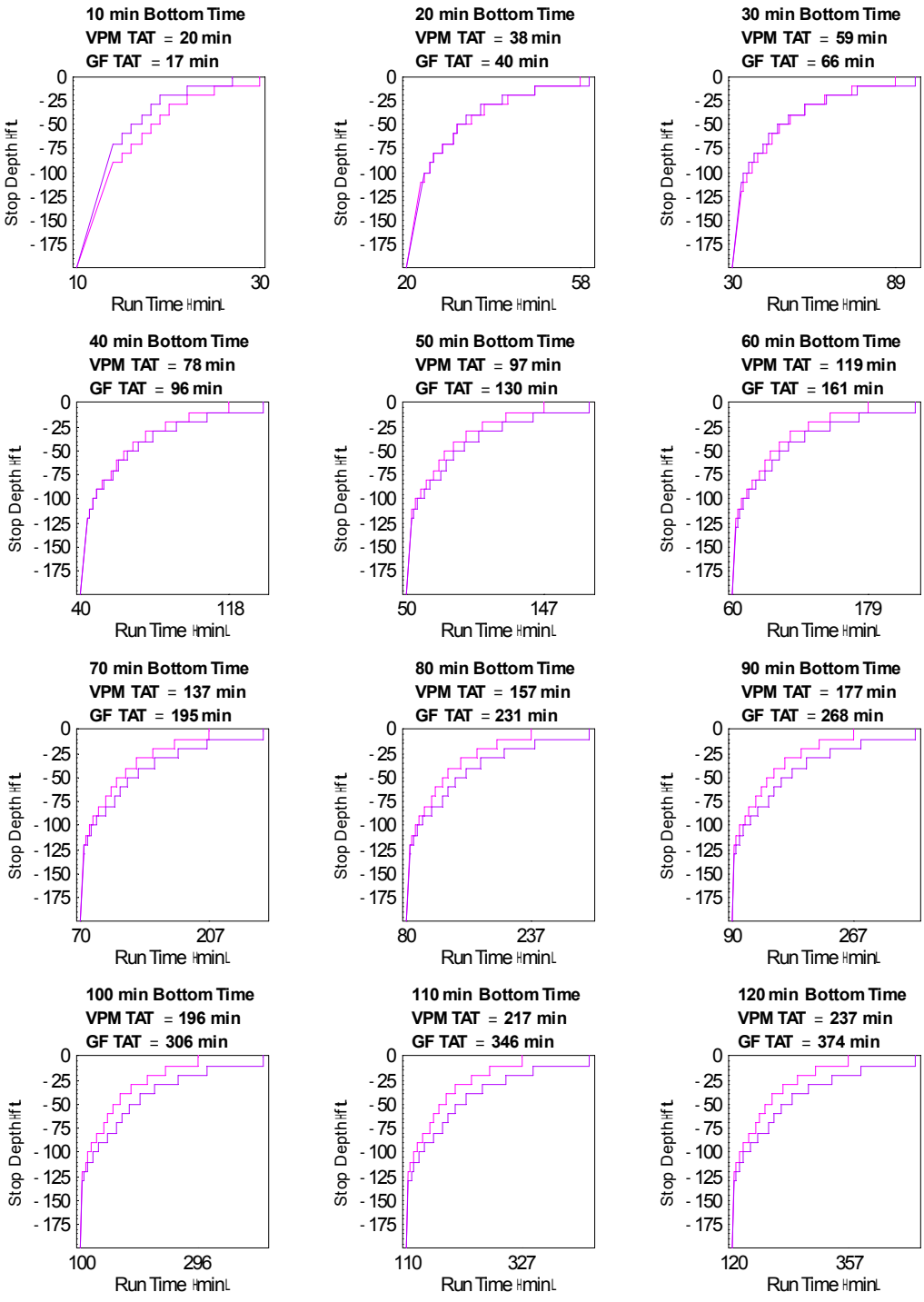
VPM-B
RGBM

Correlation of RGBM to VPM-B (2) Stop Times for Array of 200 ft Dives on Back Gas {O_2, He, N_2} = {18, 45, 37} Deco on {18, 45, 37}, {50, 0, 50}, and {100, 0, 0}



LEGEND
Deco Gases
O_2, He, N_2
100, 0, 0
50, 0, 50

Comparison of GF and VPM-B (2) Ascents for Array of 200 ft Dives on Back Gas (O2, He, N2) = (18, 45, 37) Deco on (18, 45, 37), (50, 0, 50), and (100, 0, 0)



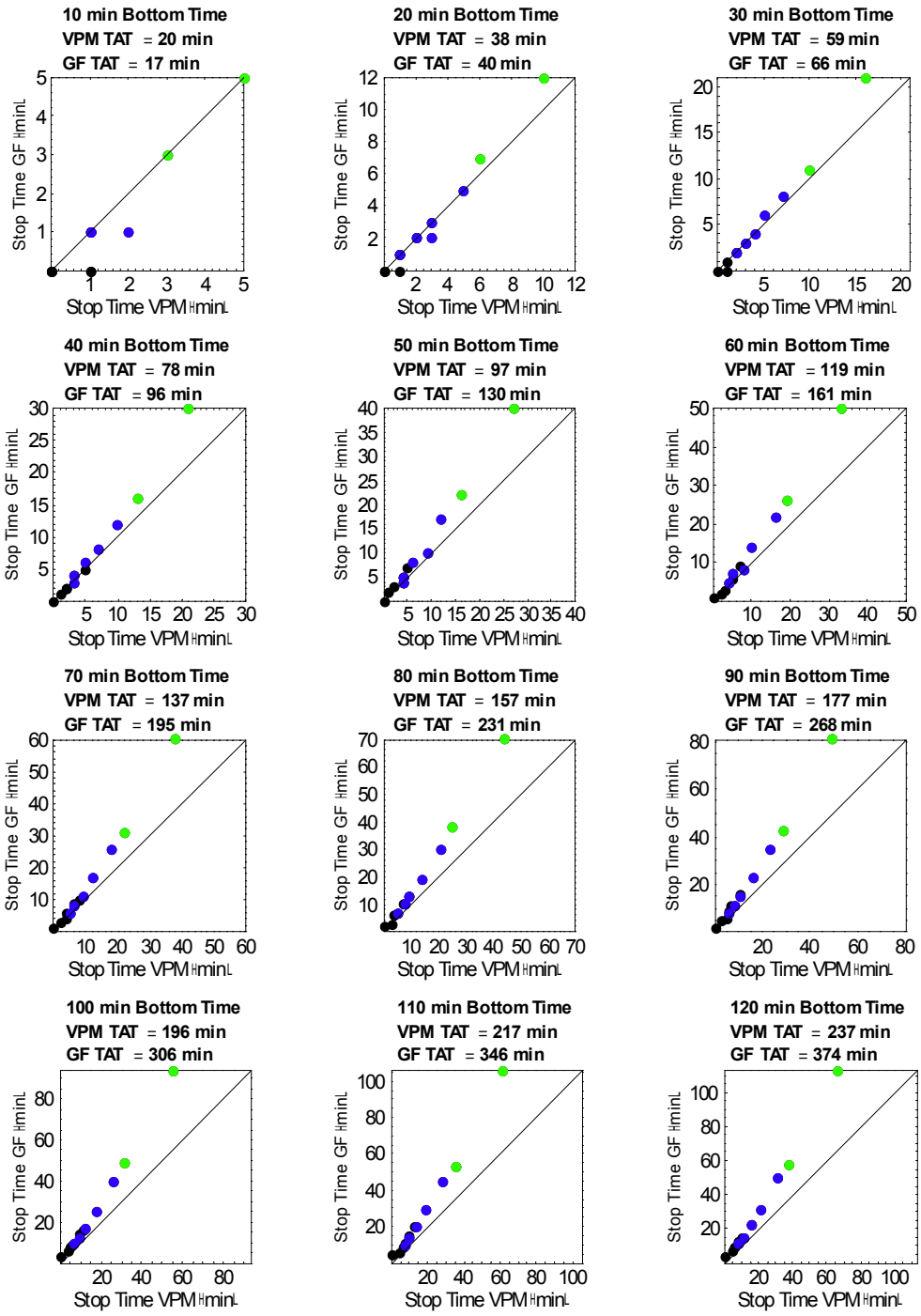
LEGEND
Dive Profiles

VPM-B
GF

Eric Maiken, 2003

Limited Distribution

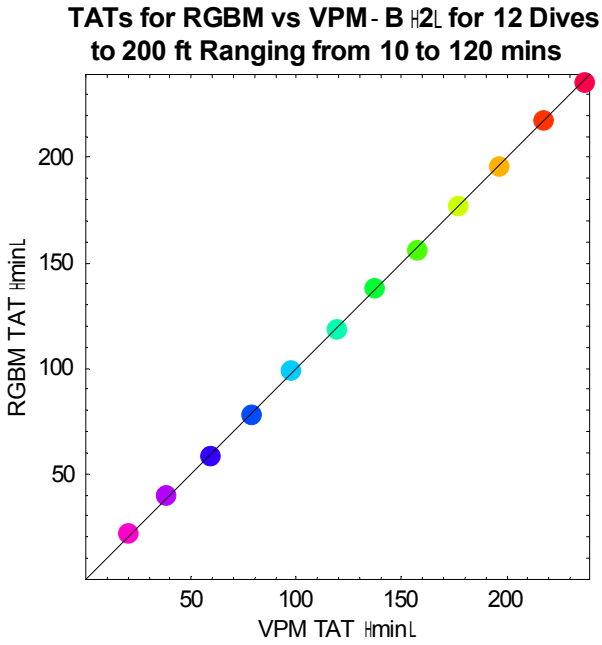
Correlation of GF to VPM-B (2) Stop Times for Array of 200 ft Dives on Back Gas {O_2, He, N_2} = {18, 45, 37} Deco on {18, 45, 37}, {50, 0, 50}, and {100, 0, 0}



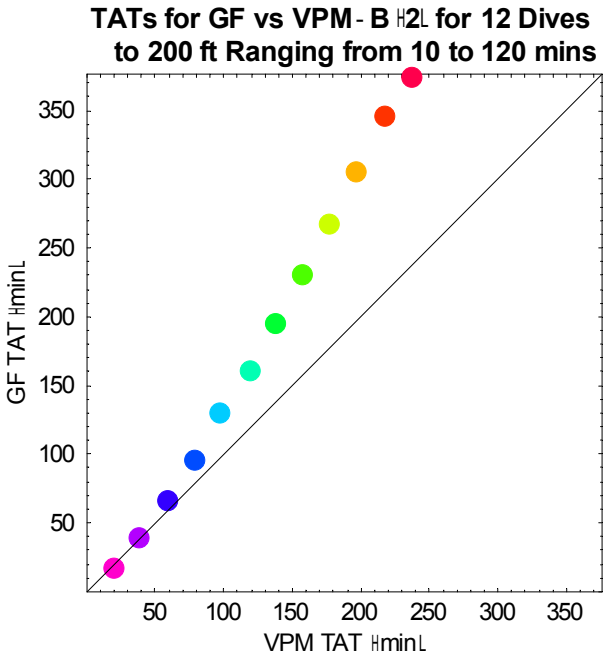
LEGEND
Deco Gases
O_2, He, N_2
100, 0, 0
50, 0, 50

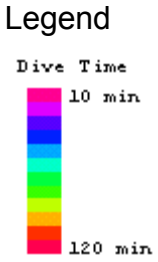
Correlation of VPM-B(2) TATs to RGBM and GF TATs for 200 ft Dives

RGBM vs. VPM-B



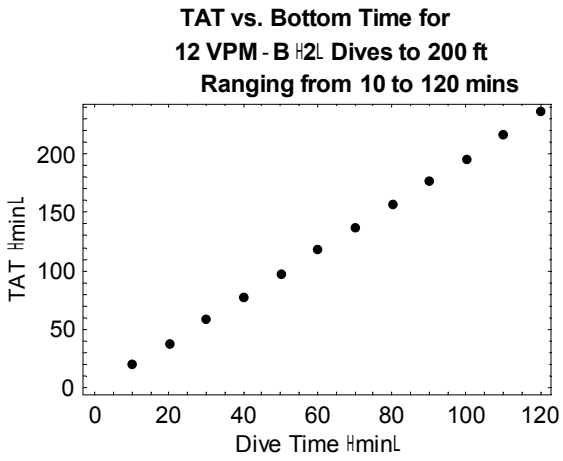
Gradient Factor vs. VPM-B

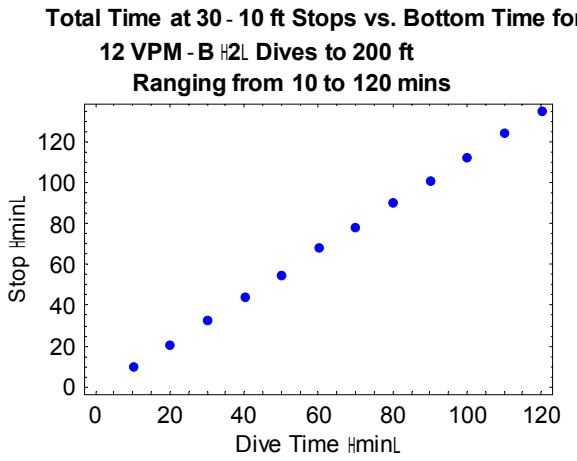


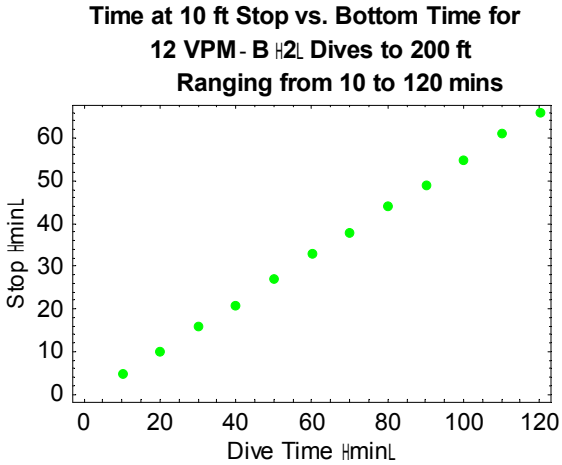


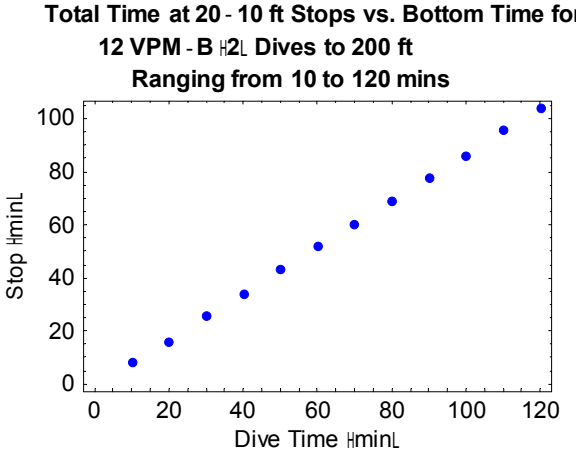
Stop Times vs. Bottom Times VPM-B Conservatism (2)

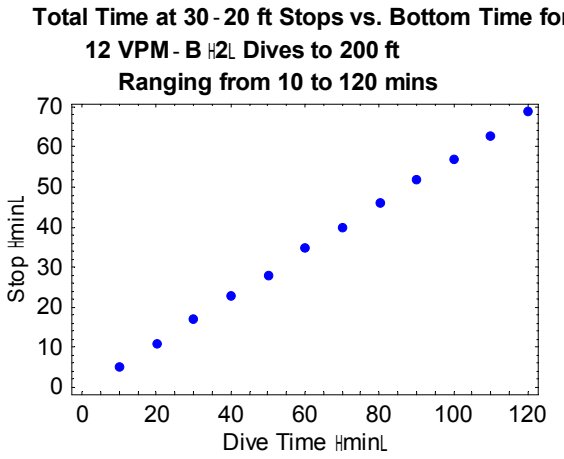
3 Deco Gases: 3mix 18/45,Nx50/50, O_2





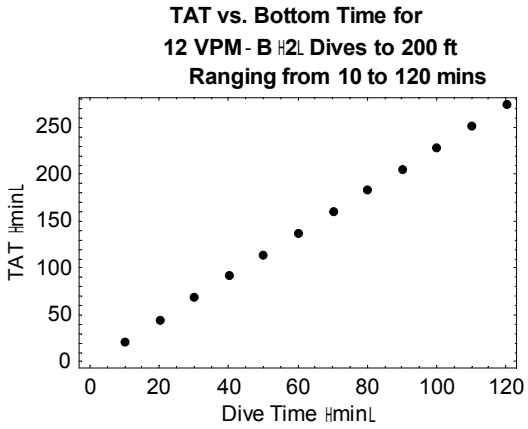


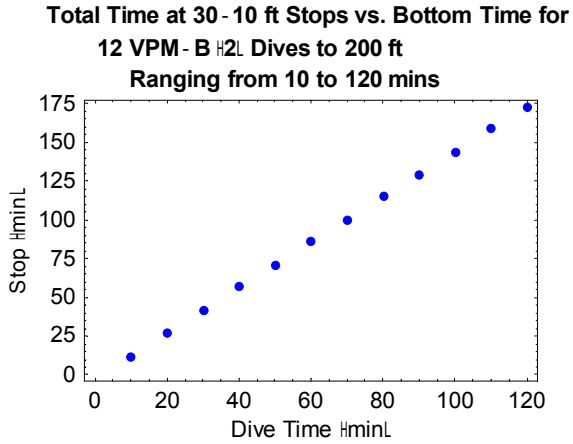


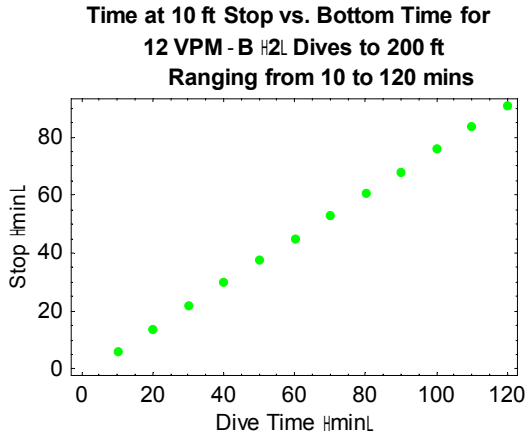


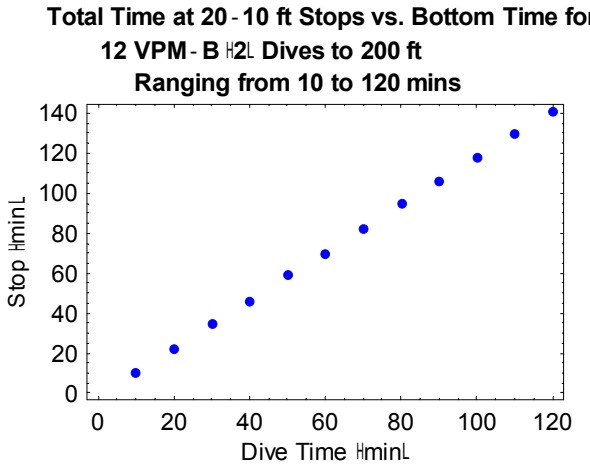
Stop Times vs. Bottom Times VPM-B(2) Lost O_2

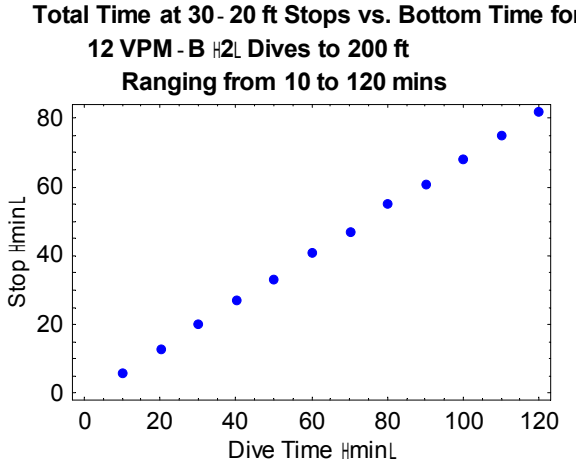
2 Deco Gases: 3mix 18/45,Nx50/50





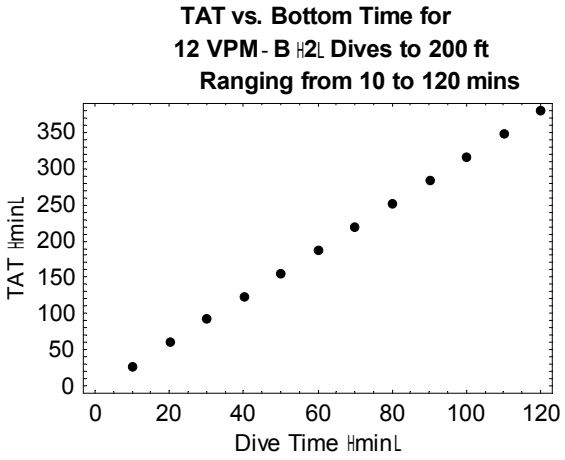


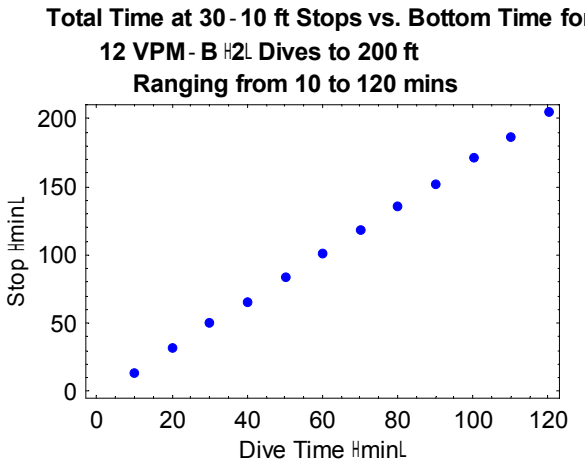


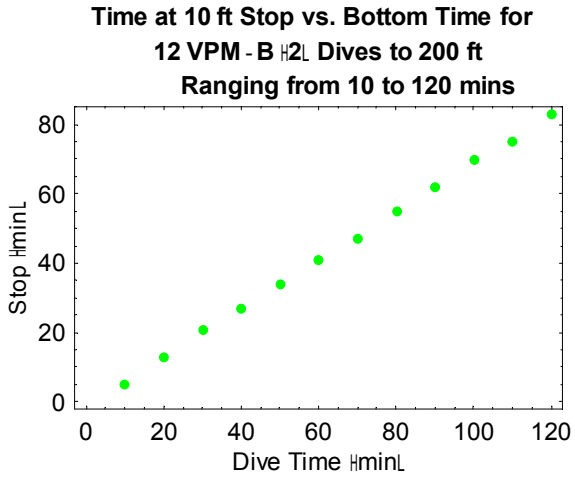


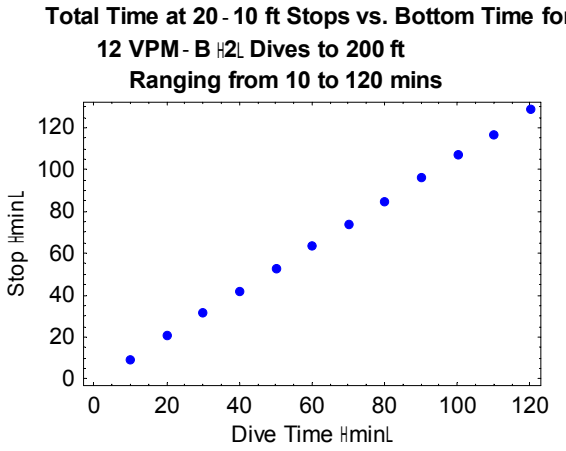
Stop Times vs. Bottom Times VPM-B(2) Lost 50-50

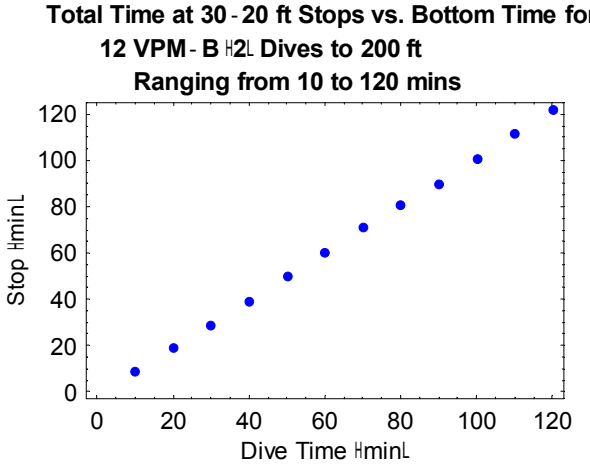
2 Deco Gases: 3mix 18/45, O_2





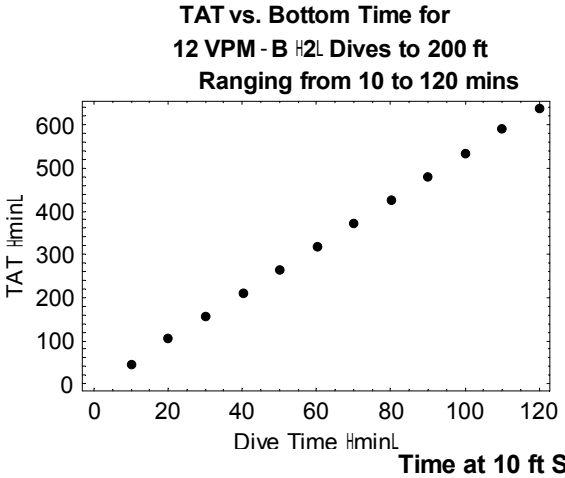


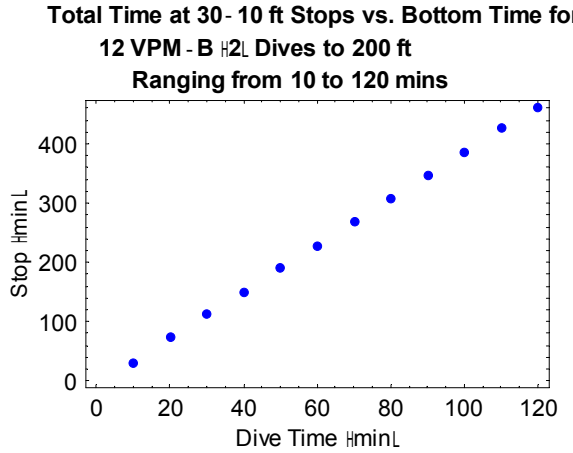


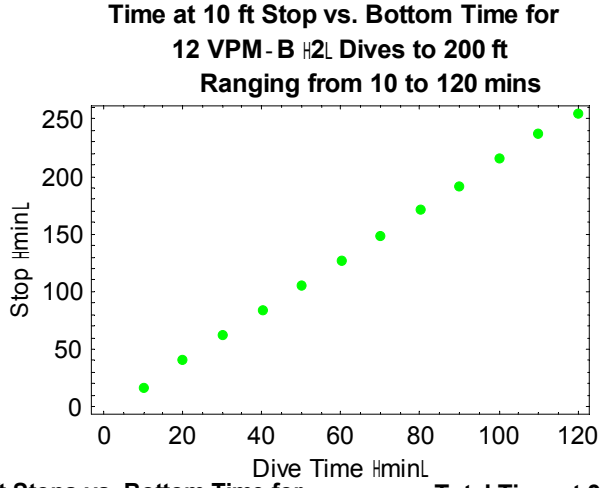


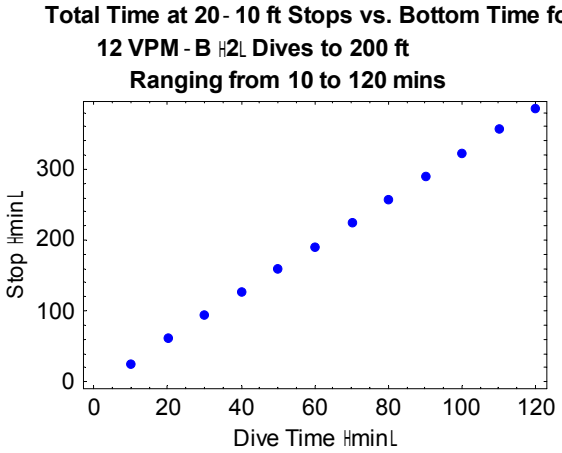
Stop Times vs. Bottom Times VPM-B(2) Lost 50-50 and O_2

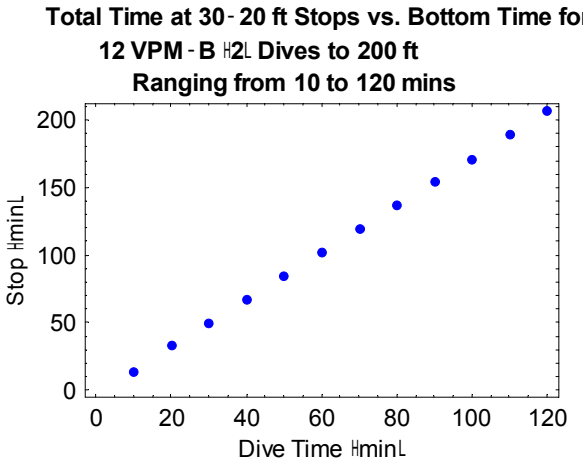
1 Deco Gas: 3mix 18/45









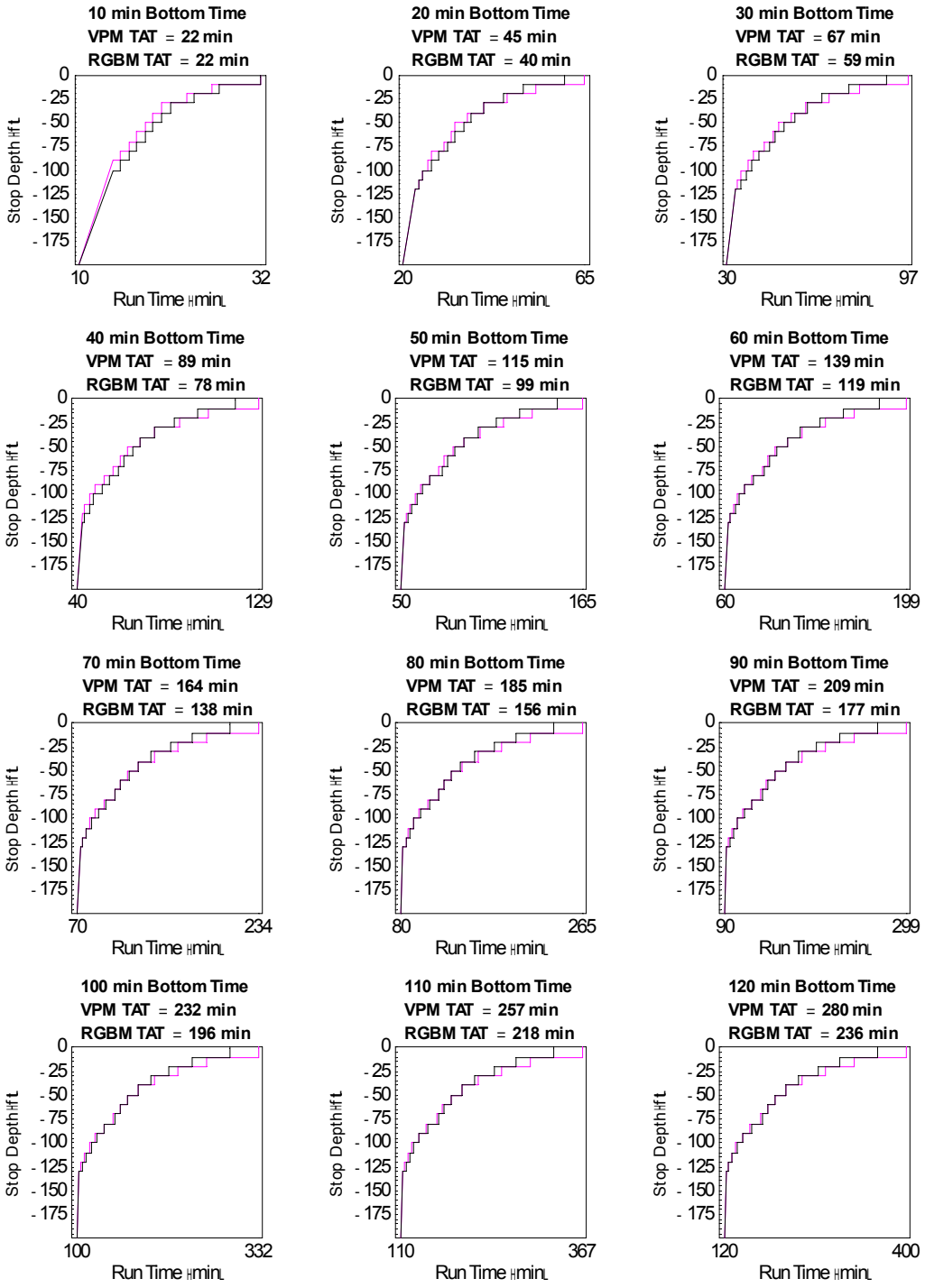


SECTION 3

Ascents from Dives at 200 ft for 10-120 min
VPM-B Conservatism Setting (4)

12 VPM-B profiles compared to RGBM and GF using full gas sets (pps. 28-32)
48 VPM-B ascents with various gases summarized (pps. 33-36)

Comparison of RGBM and VPM-B (4) Ascents for Array of 200 ft Dives on Back Gas {O_2, He, N_2} = {18, 45, 37} Deco on {18, 45, 37}, {50, 0, 50}, and {100, 0, 0}



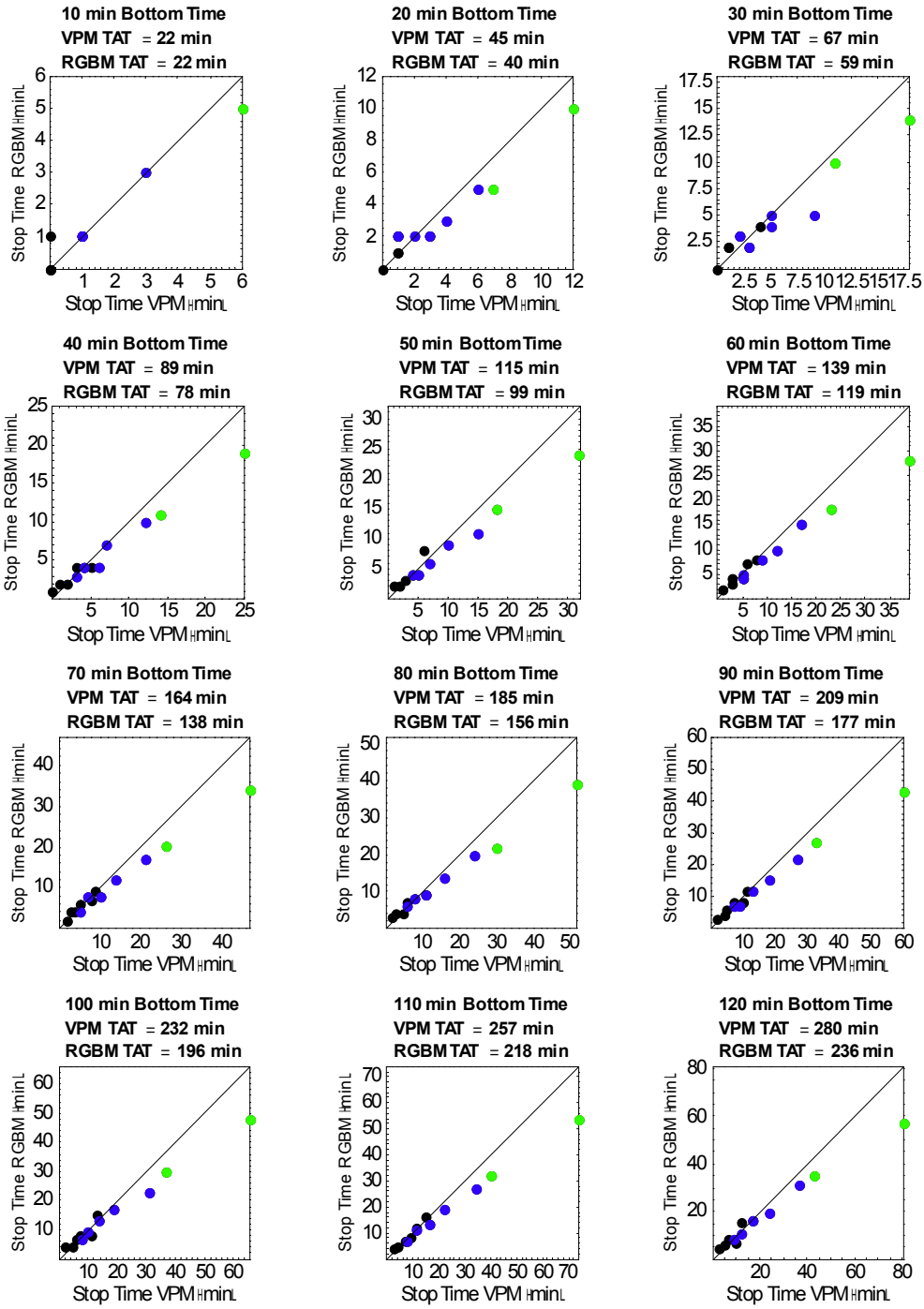
LEGEND
Dive Profiles

VPM-B
RGBM

Eric Maiken, 2003

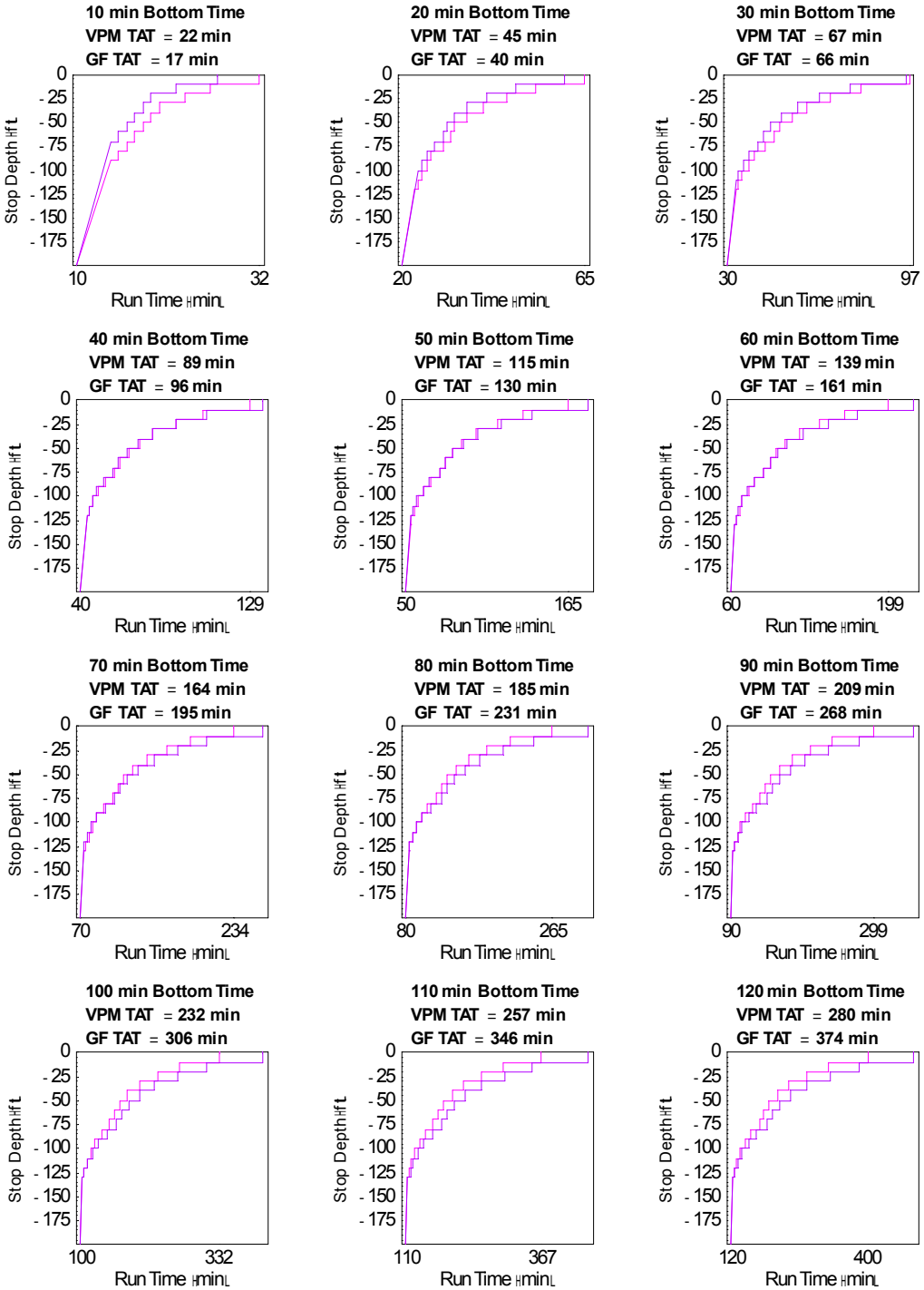
Limited Distribution

Correlation of RGBM to VPM-B (4) Stop Times for Array of 200 ft Dives on Back Gas (O2, He, N2) = (18, 45, 37) Deco on (18, 45, 37), (50, 0, 50), and (100, 0, 0)



LEGEND
Deco Gases
O_2, He, N_2
100, 0, 0
50, 0, 50

Comparison of GF and VPM-B (4) Ascents for Array of 200 ft Dives on Back Gas (18% O_2, He, N_2) = (18, 45, 37) Deco on (18, 45, 37), (50, 0, 50), and (100, 0, 0)



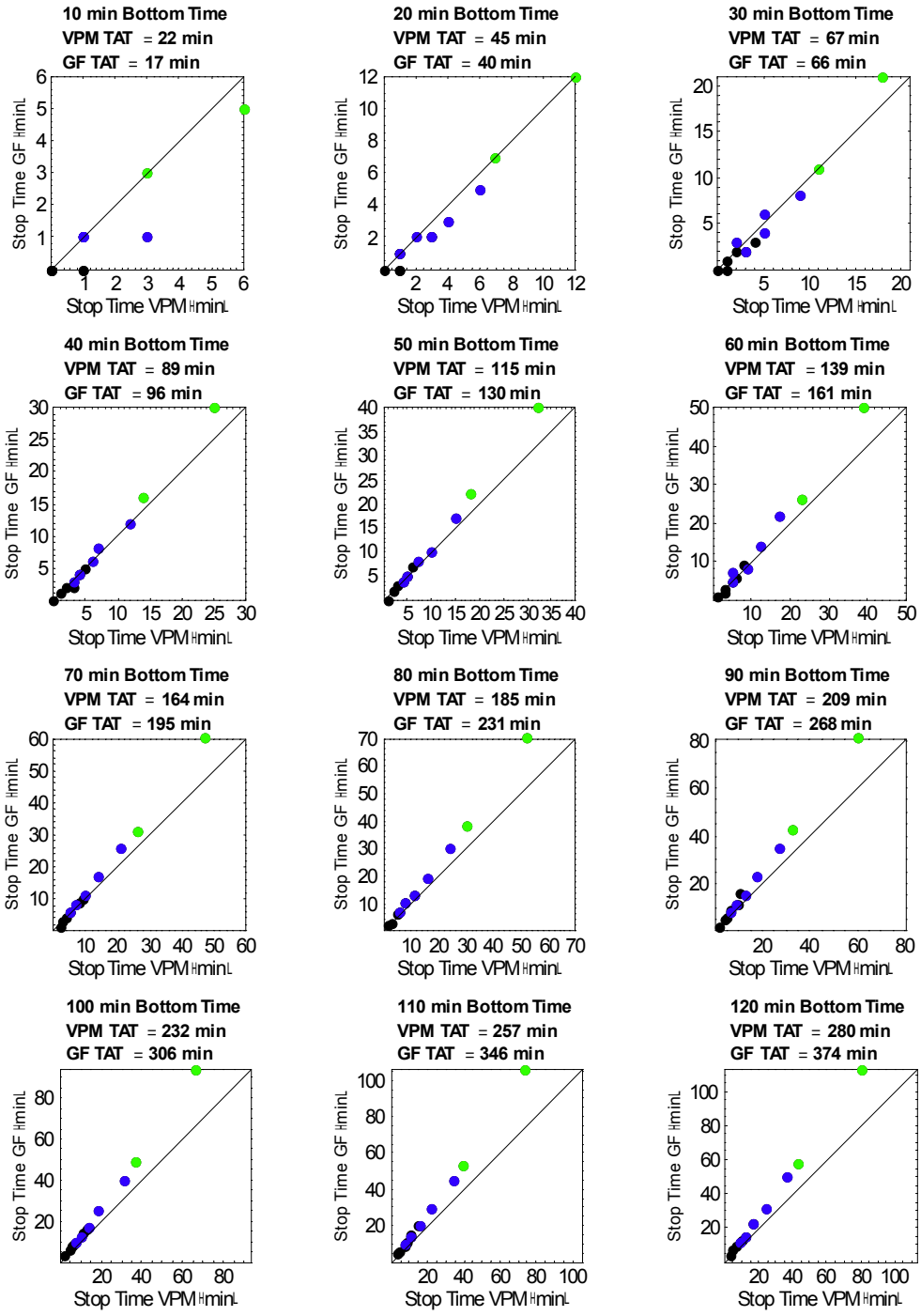
LEGEND
Dive Profiles

VPM-B
GF

Eric Maiken, 2003

Limited Distribution

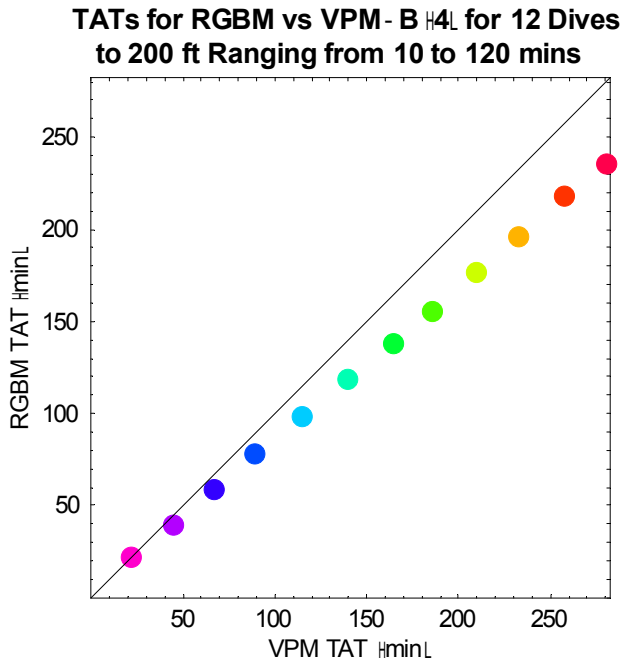
Correlation of GF to VPM - B (4) Stop Times for Array of 200 ft Dives on Back Gas (O2, He, N2) = (18, 45, 37) Deco on (18, 45, 37), (50, 0, 50), and (100, 0, 0)



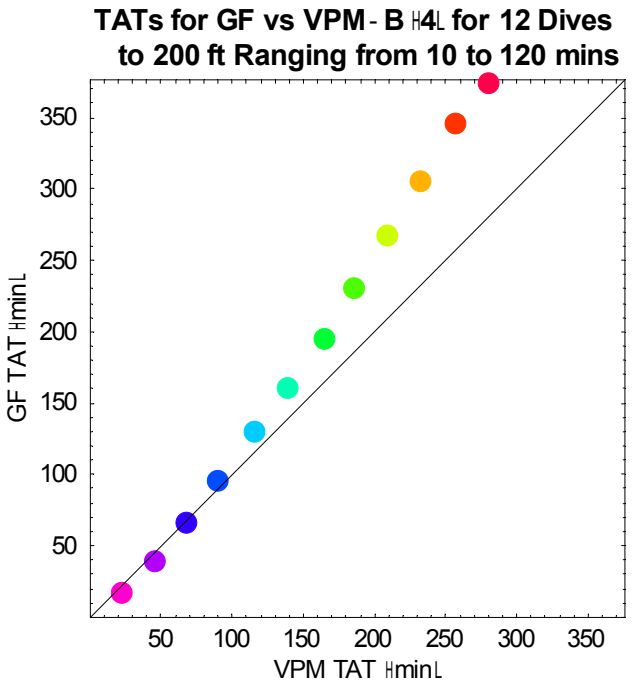
LEGEND
Deco Gases
O_2, He, N_2
100, 0, 0
50, 0, 50

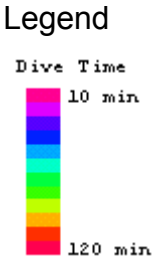
Correlation of VPM-B(4) TATs to RGBM and GF TATs for 200 ft Dives

RGBM vs. VPM-B



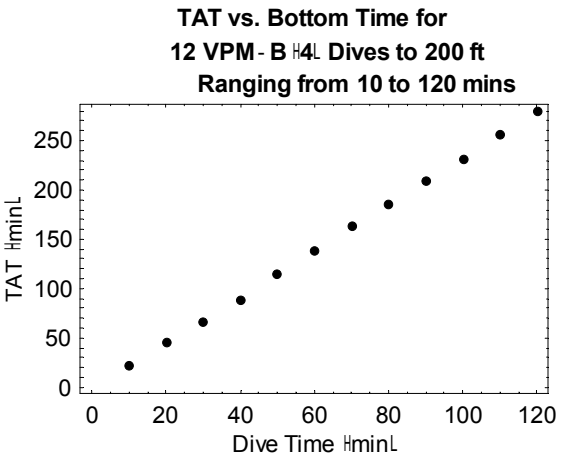
Gradient Factor vs. VPM-B

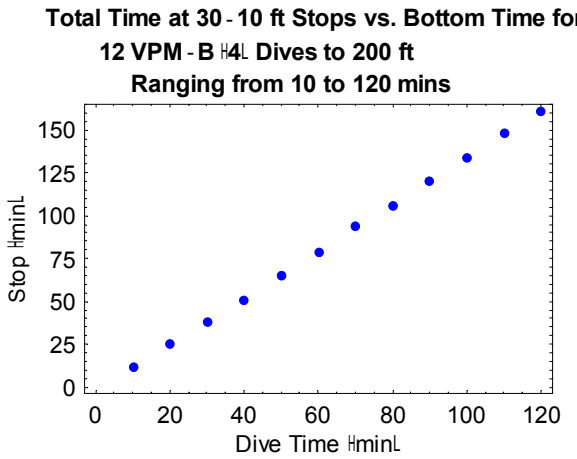


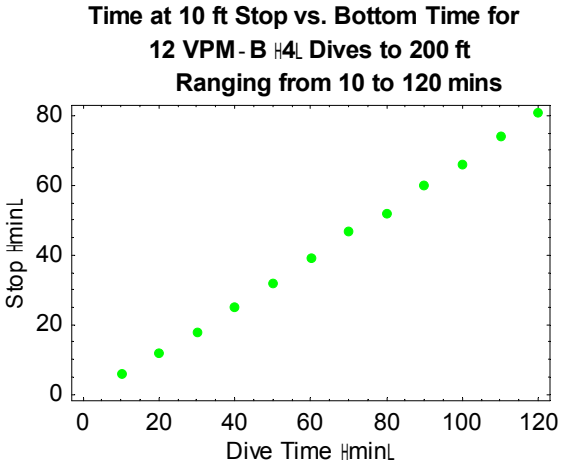


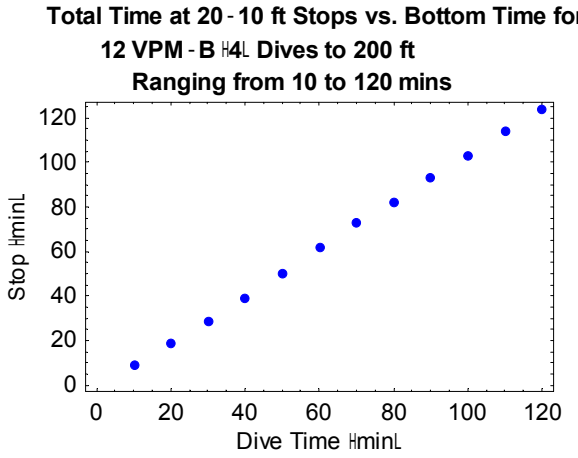
Stop Times vs. Bottom Times VPM-B Conservatism (4)

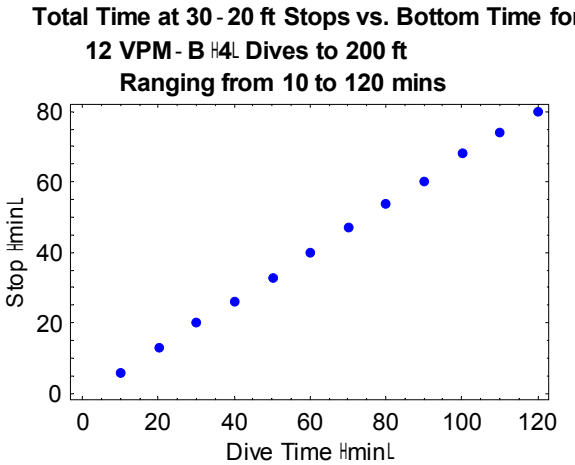
3 Deco Gases: 3mix 18/45,Nx50/50, O_2





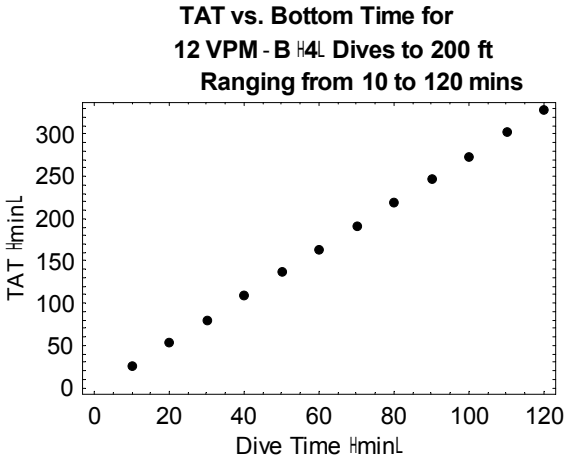


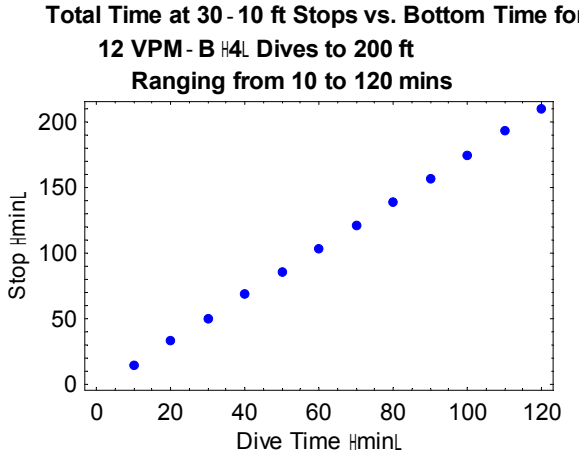


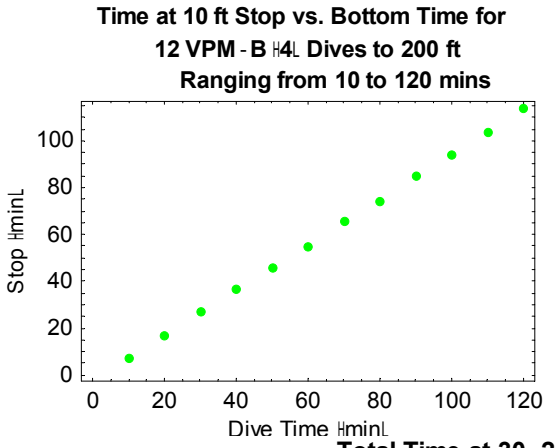


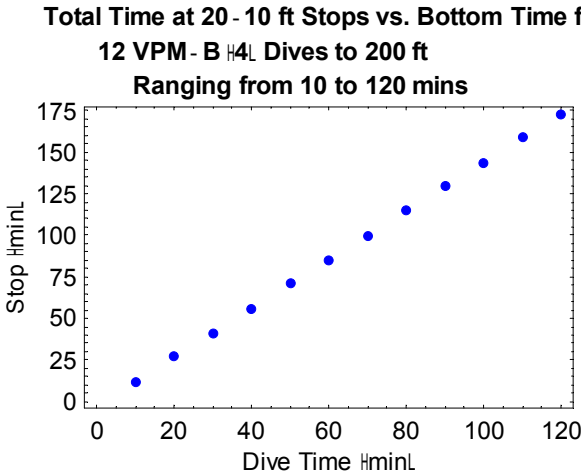
Stop Times vs. Bottom Times VPM-B(4) Lost O_2

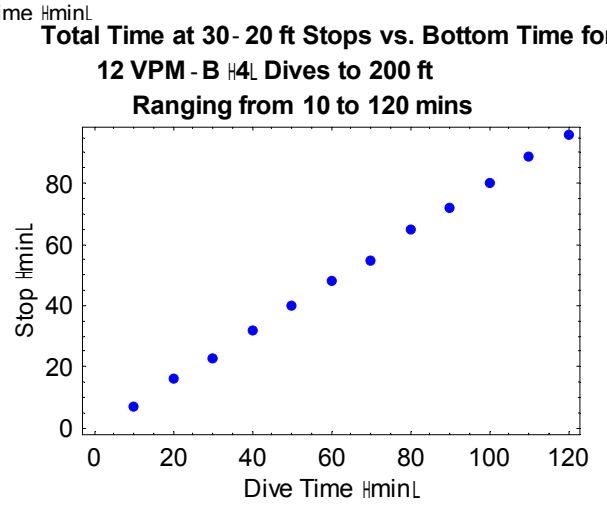
2 Deco Gases: 3mix 18/45,Nx50/50







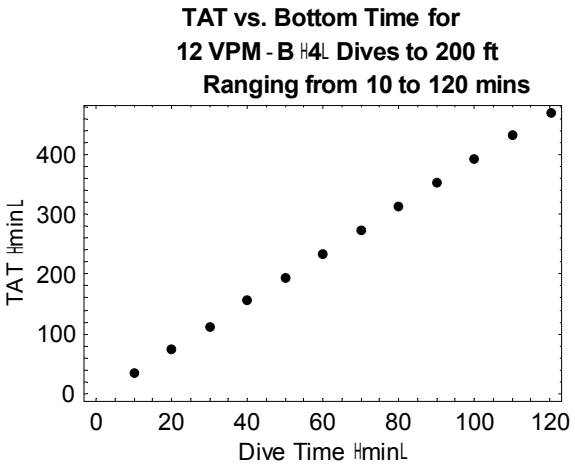


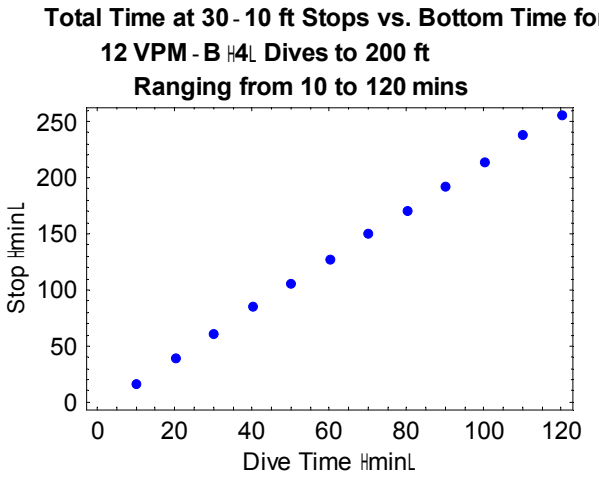


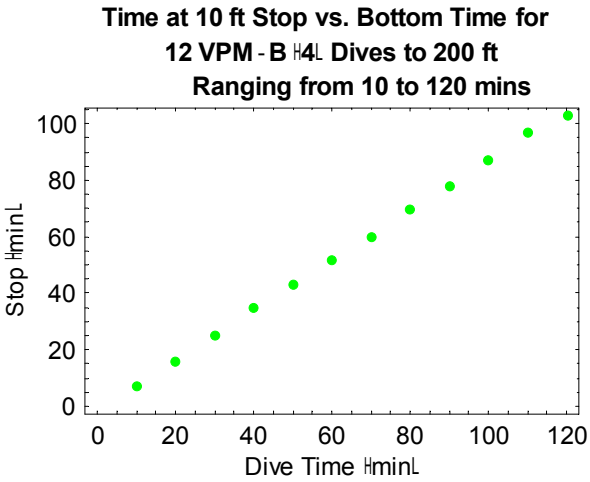
Eric Maiken, 2003 Limited Distribution

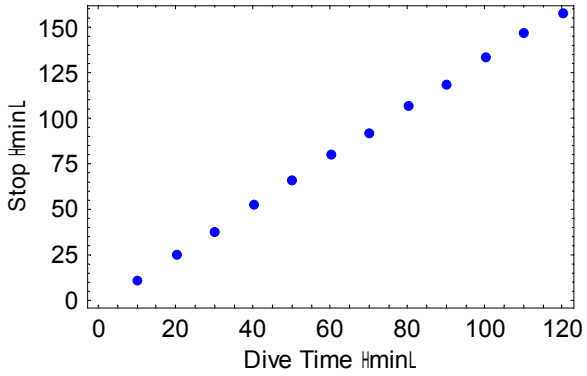
Stop Times vs. Bottom Times VPM-B(4) Lost 50-50

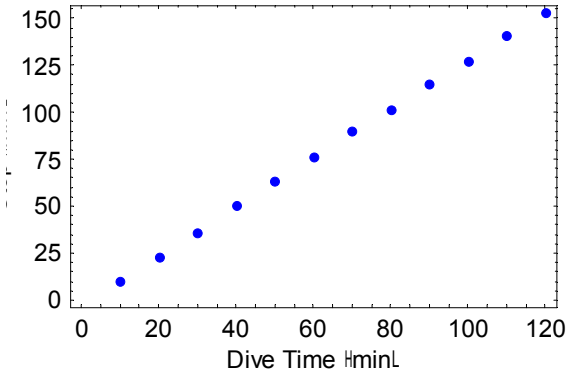
2 Deco Gases: 3mix 18/45, O_2





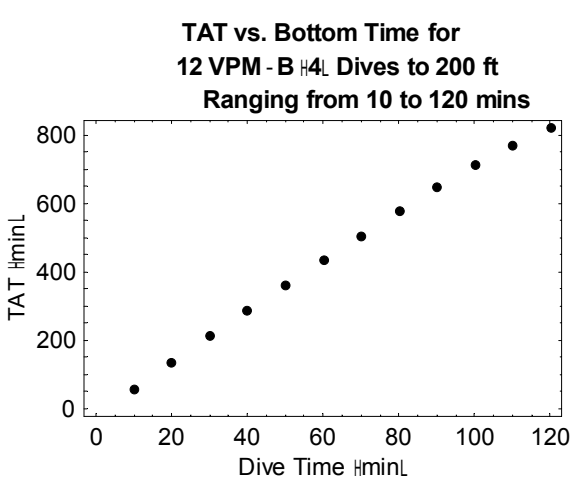


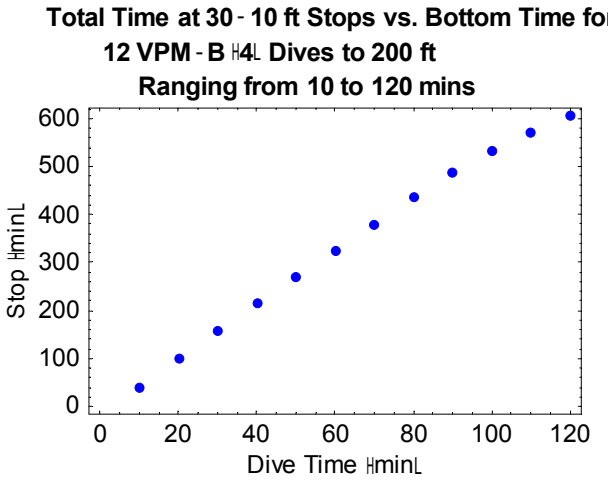


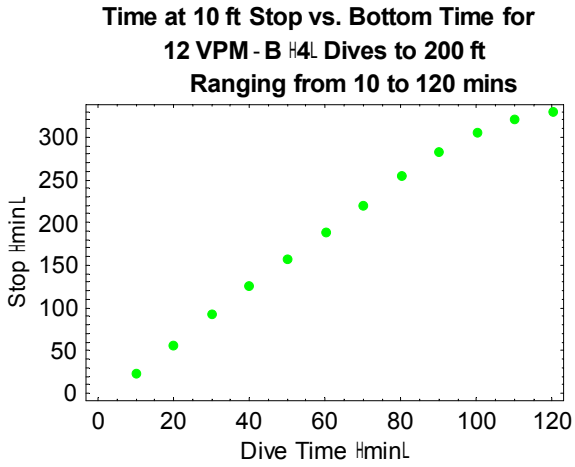


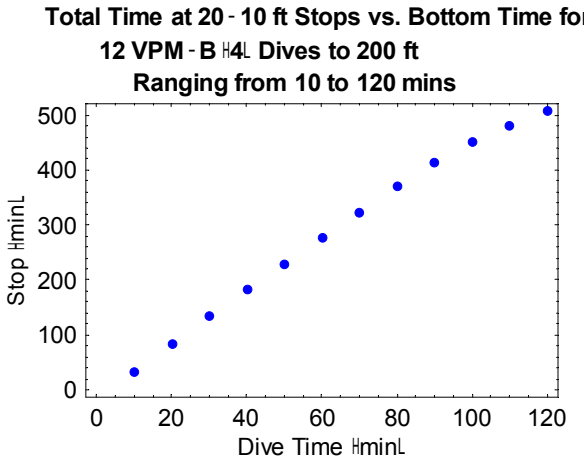
Stop Times vs. Bottom Times VPM-B(4) Lost 50-50 and O_2

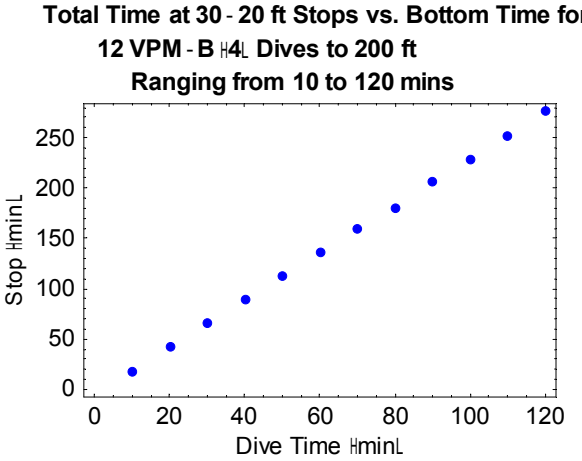
1 Deco Gas: 3mix 18/45











SECTION 4

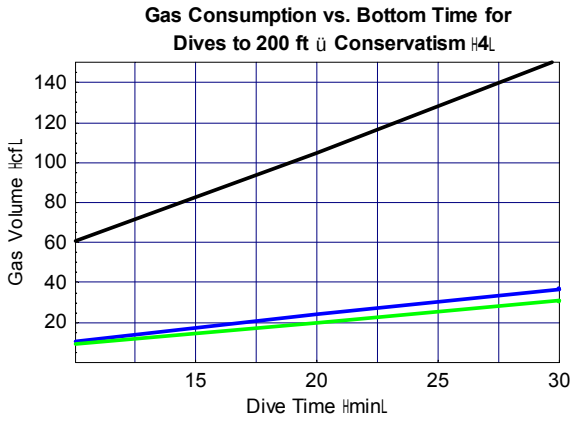
Dive Planning

Gas Consumption vs. Dive Time

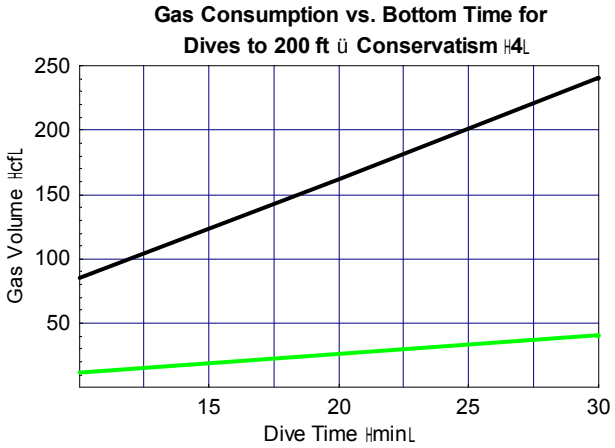
SCR = 0.66 cubic feet per minute = 0.66 x 28.23 liters per minute.

Conservative conclusion: The maximum dive time of 20-min is determined by ability to self-support all decompression under any gas contingency (lost gas, lost buddy, etc.), with tables calculated as VPM-B(4).

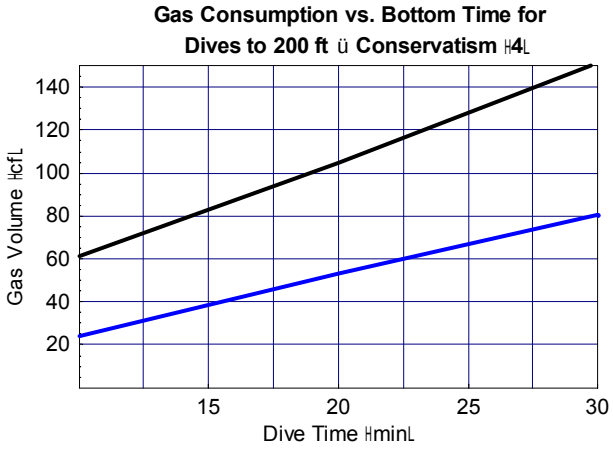
3 Deco Gases: 3mix 18/45,Nx50/50, O_2



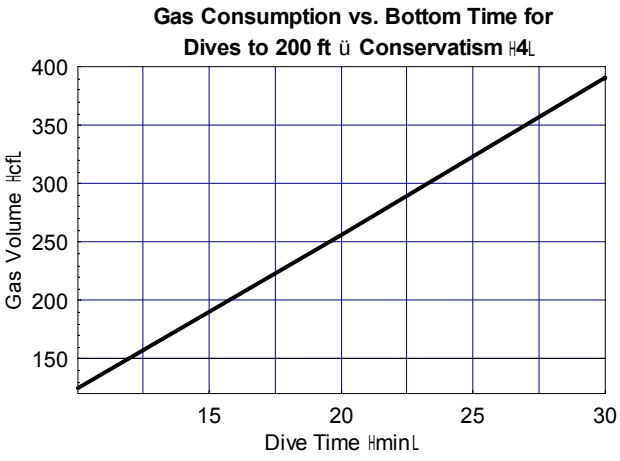
2 Deco Gases: 3mix 18/45, O_2



2 Deco Gases: 3mix 18/45,Nx50/50



1 Deco Gas: 3mix 18/45



LEGEND
Deco Gases
O_2, He, N_2
100, 0, 0
50, 0,50