

A new class of biophysical models for predicting the probability of decompression sickness in scuba diving

Articles in PresS. J. Appl. Physiol (April 19, 2007). doi:10.1152/japplphysiol.00315.2006

Saul Goldman

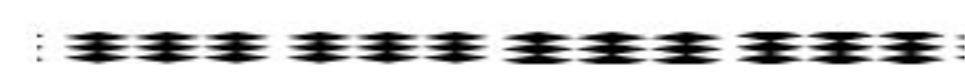
Department of Chemistry and the Guelph-Waterloo Physics Institute, University of Guelph, Guelph, Ontario, N1G 2W1, Canada

e-mail: sgoldman@uoguelph.ca

Web: <http://www.chemistry.uoguelph.ca/goldman/>

RELATED EARLIER WORK

1. **MF Morales and RE Smith's** "Competitive Parallel Arrangement". (1944-48).
2. **John A Jacquez** "Compartmental Analysis in Biology and Medicine" (1985).
3. **RD Vann.** "Mechanisms and Risks of Decompression". (1990).
4. **JA Novotny *et. al.***, "Xenon kinetics in muscle..." (1990).
5. **DJ Doolette *et. al.*** Multiexponential models for data on sheep (1998-2005).



THE PROBABILISTIC APPROACH TO DECOMPRESSION MODELING
DEVELOPED BY PK WEATHERSBY et al IS USED

$$P_N(DCS) \approx 1 - \exp(-R)$$

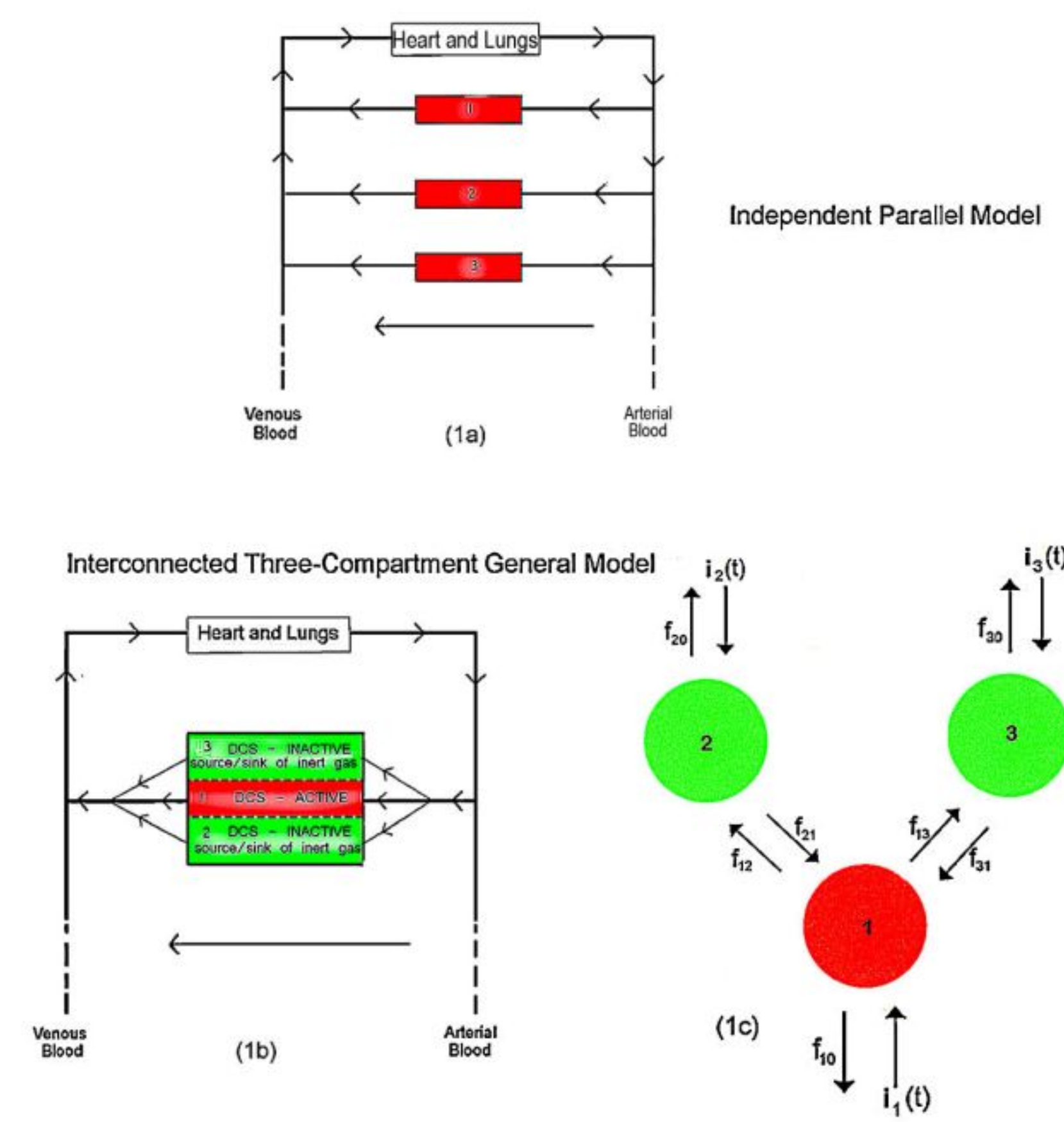
$$r_i(t) \quad Q(N_2; solution) \quad ? \quad ? \quad ? \quad ? \quad ? \quad ? \quad ? \quad ?$$

CALIBRATION OF THE MODELS

Square profiles only with air as the breathing mixture was used for all the calibration s.

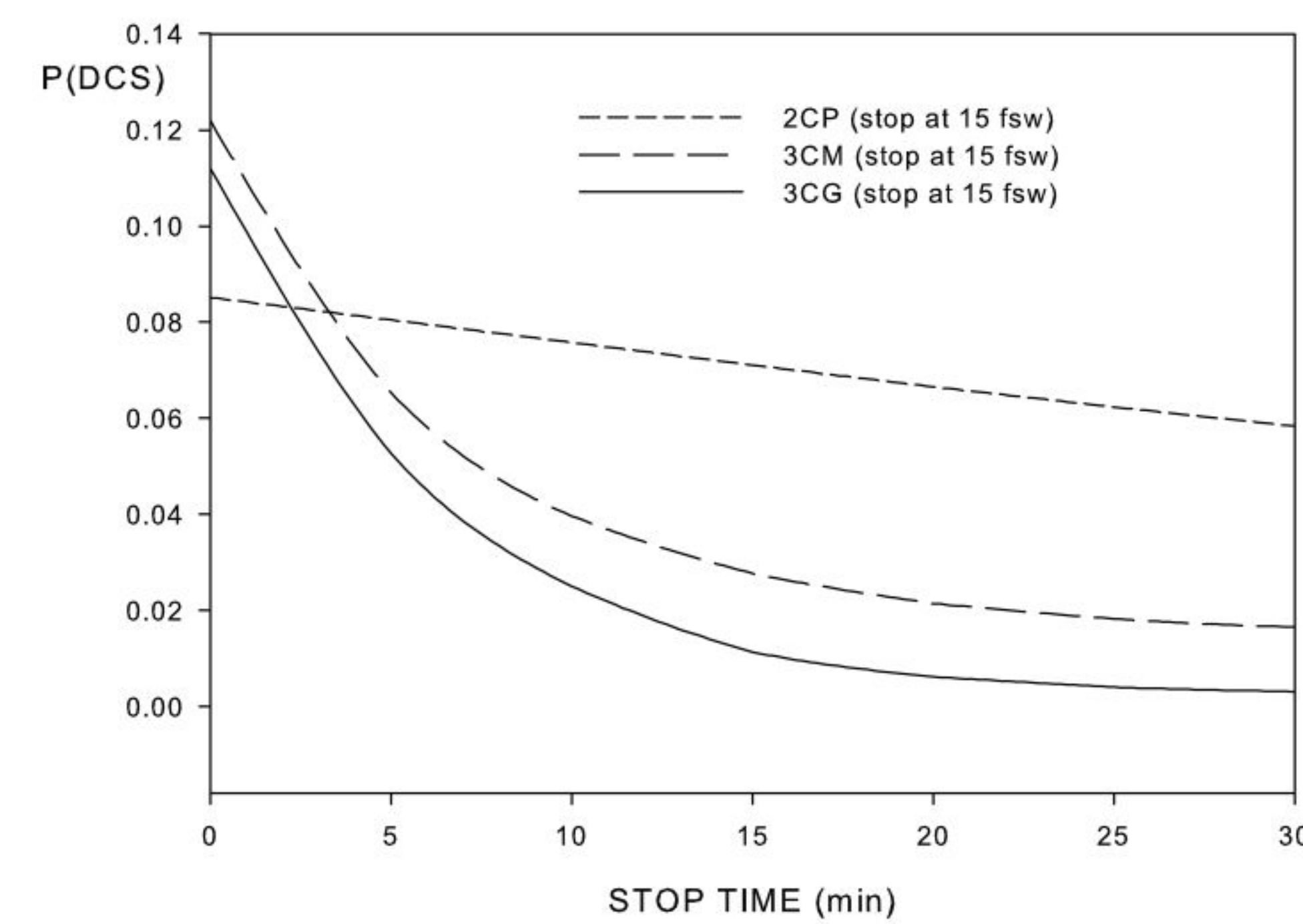
This was done so as to test model robustness , i.e. the capacity of the models to extrapolate beyond the calibration regime.

“Maximum Likelihood” was used to determine the model parameters.

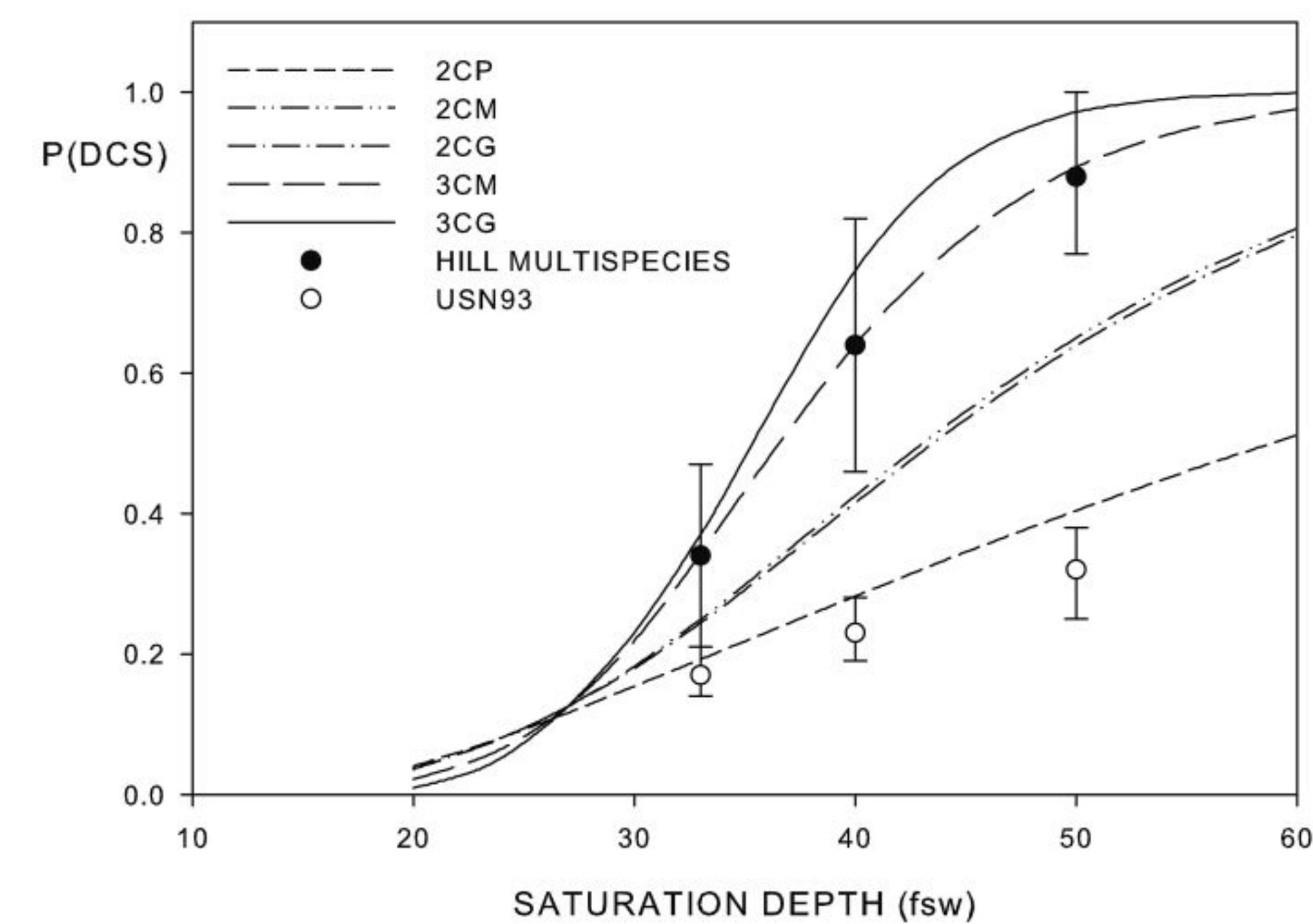


EFFECT OF STOP TIME ON P(DCS)

DIVE: 120 fsw, 30 min



EXTRAPOLATION TO VERY HIGH-RISK PROFILES



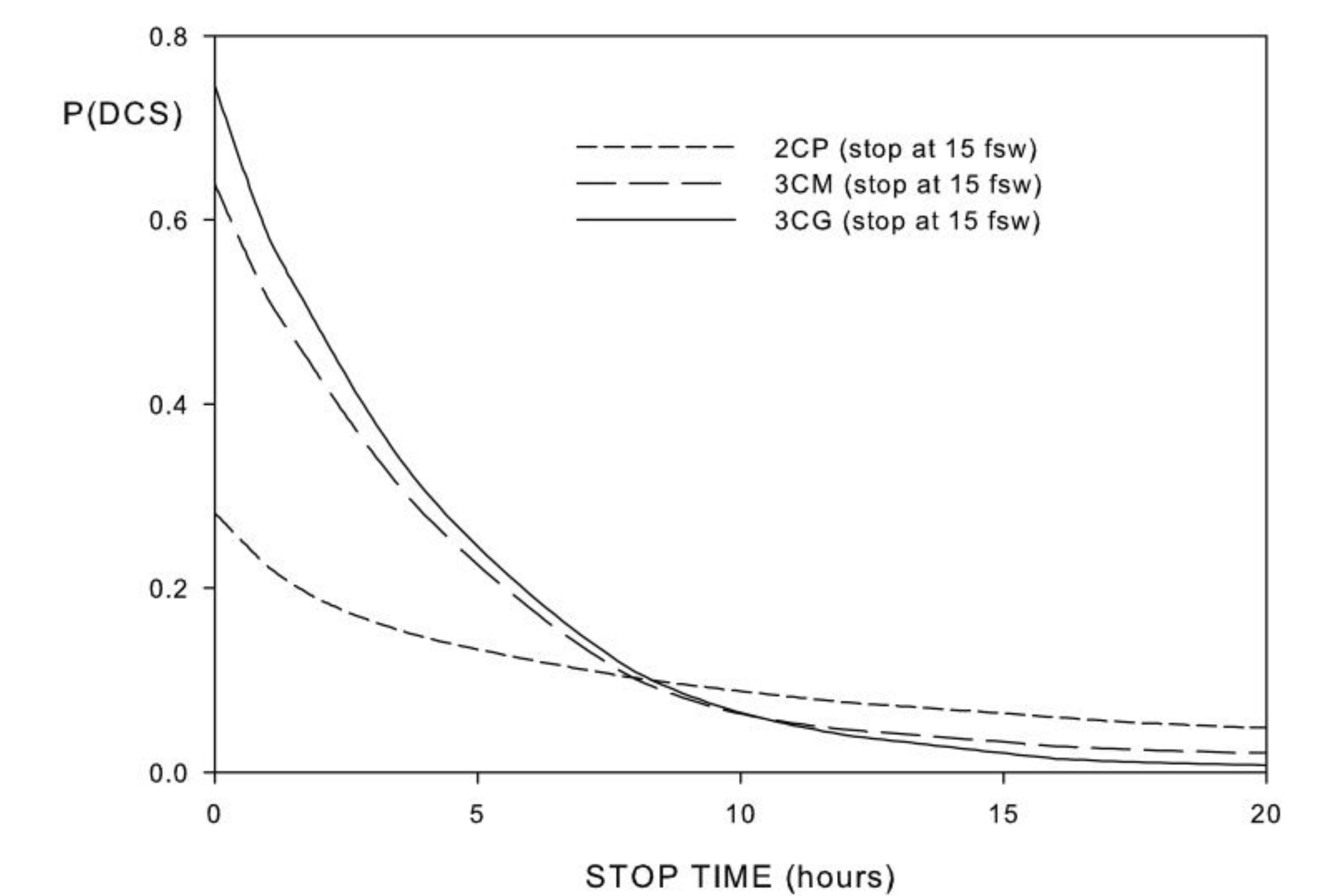
EXTRAPOLATION TO VERY LOW-RISK PROFILES

Probability of consistency with datasets used to validate the recreational dive planner. Entries in parentheses are " χ^2 " values; ν = # degrees of freedom.

Dataset	# single dives	# dive sets	# dive profiles (ν)	2CP	3CM	3CG
Phase 1	911	437	25	$.35 \times 10^{-3} (56.1)$	$.36(26.7)$	$.98(12.6)$
Phase 1+2B	1386	557	31	$.50 \times 10^{-4} (71.4)$	$.24(36.2)$	$.93(20.2)$
Phase 1+2A+2B	1437	565	33	$.71 \times 10^{-4} (73.2)$	$.25(38.0)$	$.93(21.9)$

EFFECT OF STOP TIME ON P(DCS)

DIVE: 40 fsw, 24 hours



Conclusions

1. The 3CM and 3CG models extrapolate beyond the calibration regime much more accurately than does the 2CP model. These models were calibrated using the identical dataset, made use of the same risk function, were based on linear kinetics, and had the same number of adjustable parameters (4).
2. The greater rate of risk abatement during a safety or decompression stop predicted by the interconnected models is due to their relatively rapid initial washout rate of nitrogen from their central risk-bearing compartment.
3. The P(DCS) calculations with the interconnected models can be done very rapidly and accurately. The time for a P(DCS) calculation for a single profile is in the range (.001-.01) seconds using a standard (2.8GHz) PC.