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Navy Experimental Diving Unit

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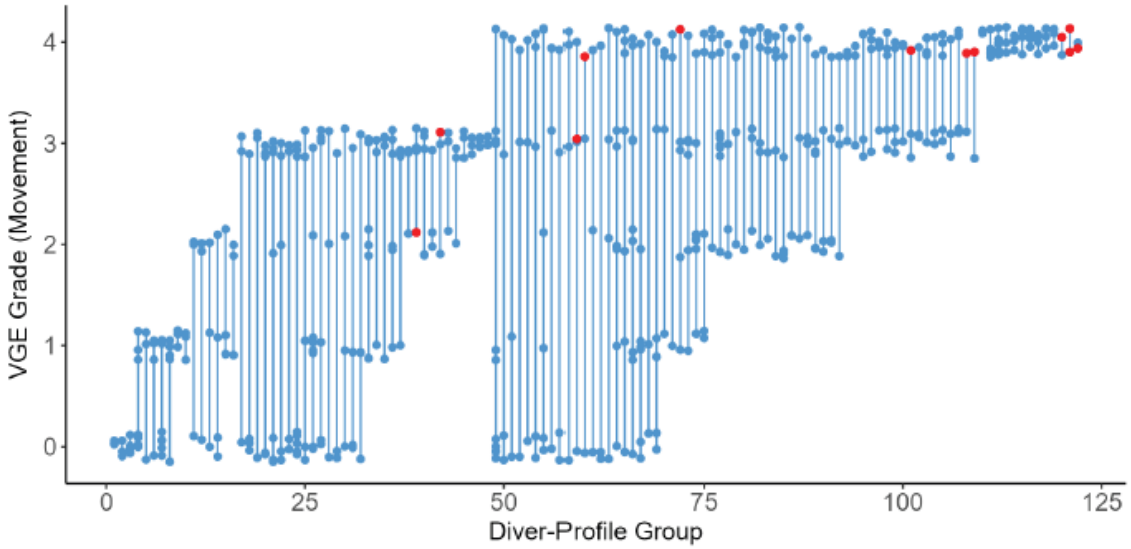


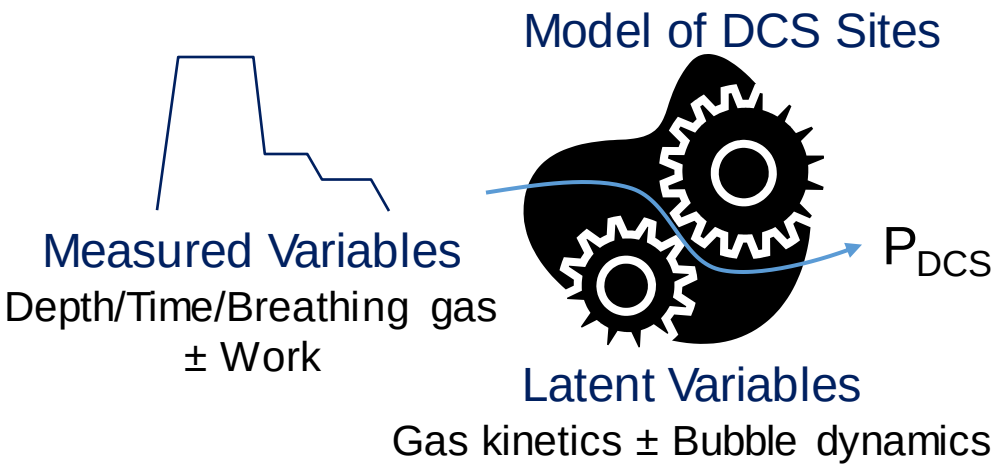
Marked within-diver variability in decompression outcomes following identical dives

Decompression schedules computed from depth/time/breathing gas ± work ± temperature cannot eliminate risk of DCS (P_{DCS})

Implications for:

- Estimating P_{DCS}
- Decompression sickness pathophysiology
- Real-time control of decompression

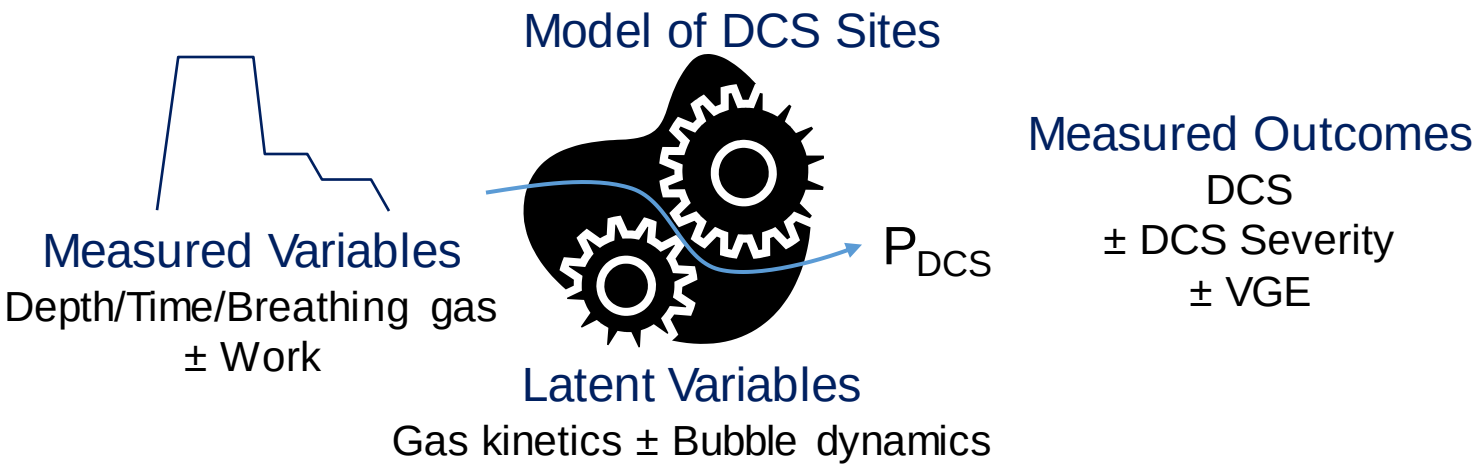
Probabilistic Decompression Models



Measured Outcomes
DCS
± DCS Severity
± VGE

- Statistically formal vs legacy trial-and-error approach
- Estimate P_{DCS} of dive profiles
- Generate schedules at target P_{DCS}
- Underlies most U.S. Navy decompression procedures
- Fragile capability: pending retirements reduces workforce to 1-2 worldwide

The Future of Probabilistic Decompression Models



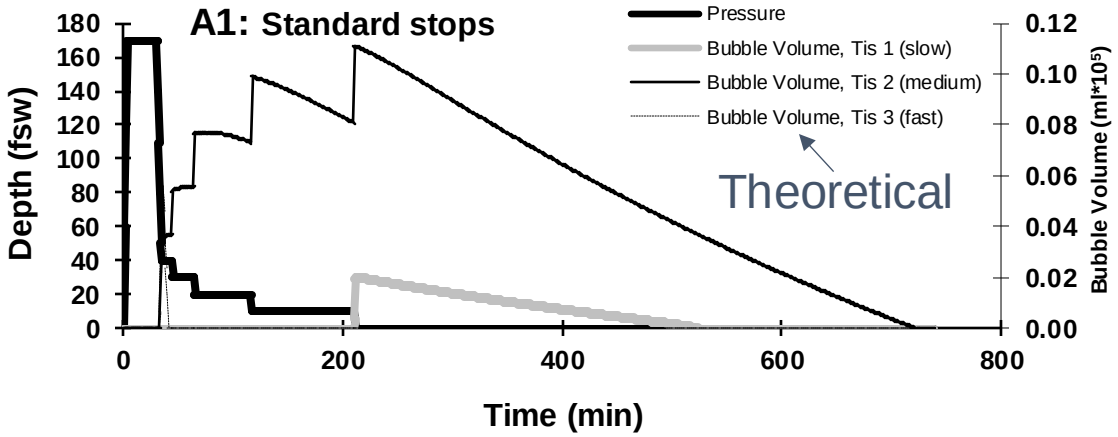
- ✗ Elaborating with more latent variables not useful
- Elucidate DCS mechanisms to fix model parameters
  - Acute musculoskeletal pain and spinal manifestations prevalent in calibration data
  - VGE/extravascular bubble relationships

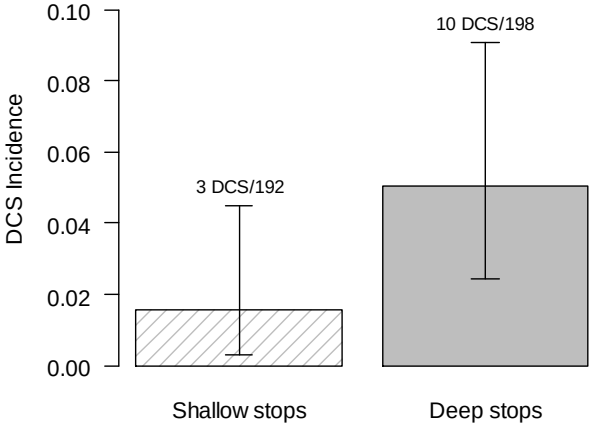
Cause of Variability in DCS Susceptibility

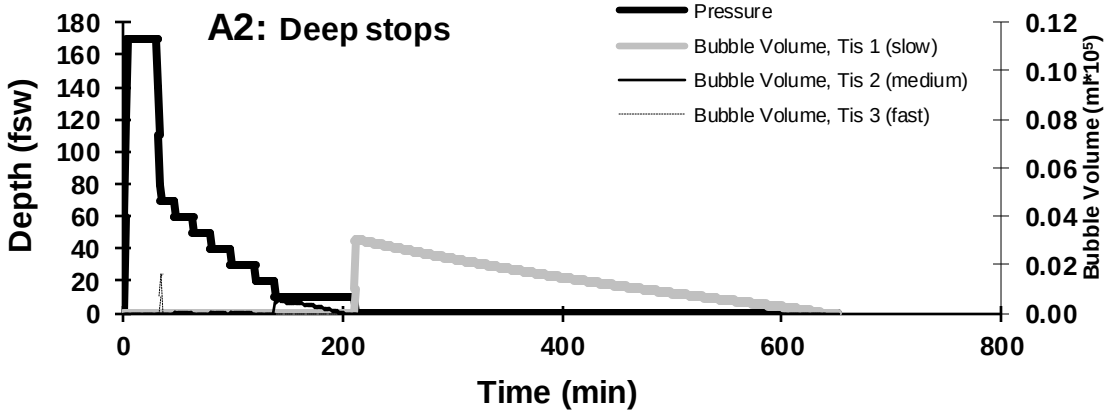
- Previous paradigm: “individualized decompression” tacitly assumes stable between-diver variability
- New paradigm: day-to-day variability
  - Operational utility would require daily assessment
    - ✗ Obtain and analyze biospecimen
    - ✓ Easily observed and modified status
  - Experimental control / covariates
- VGE/DCS correspondence suggests focus on gas kinetics and bubble dynamics

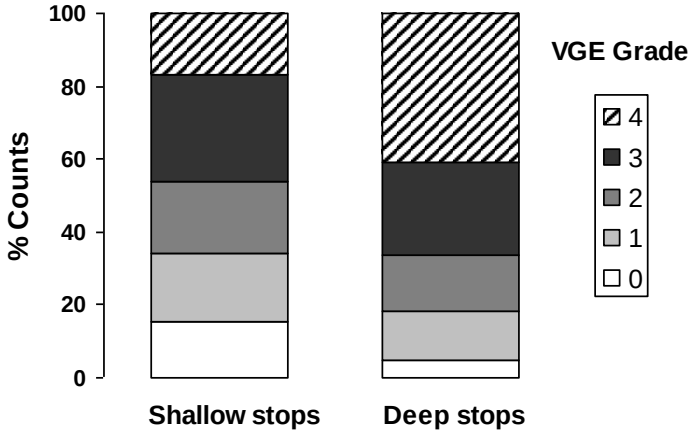
NEDU Deep Stops Trial

Results



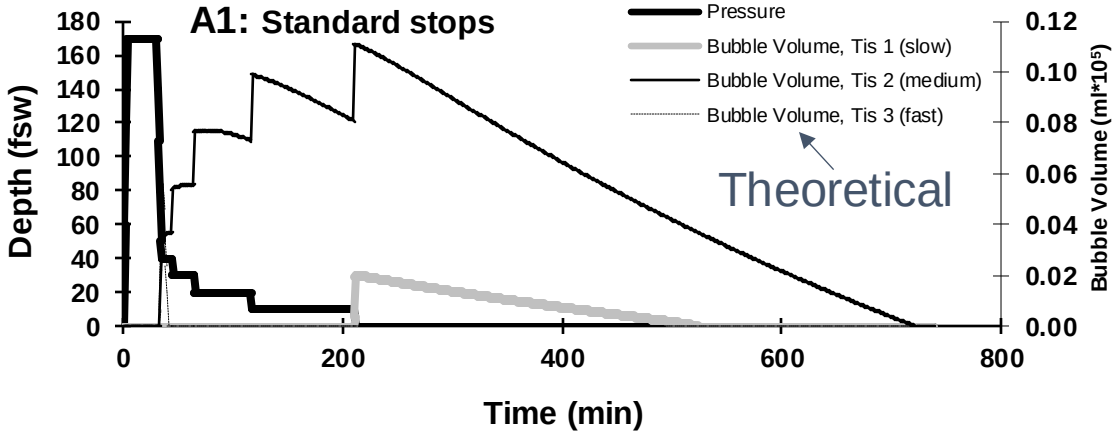


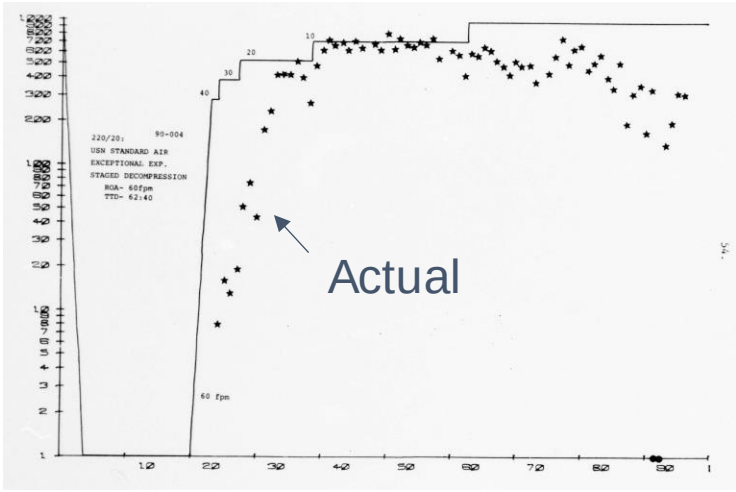


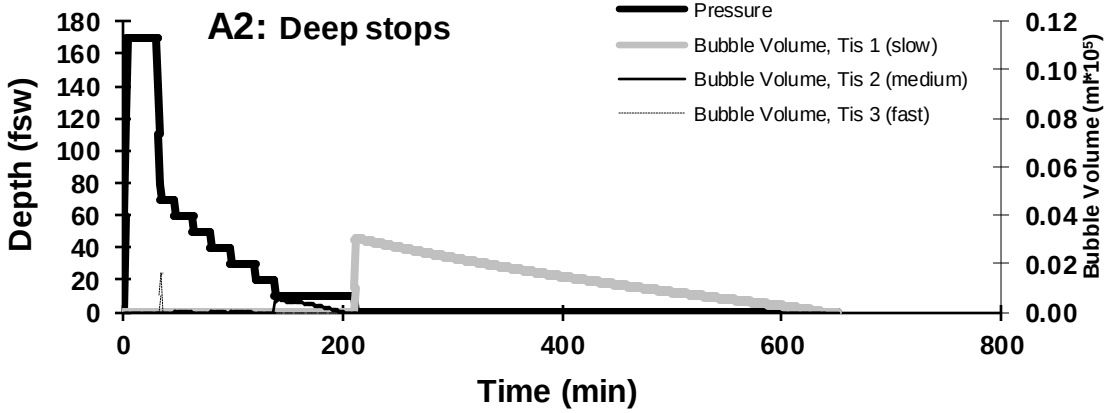


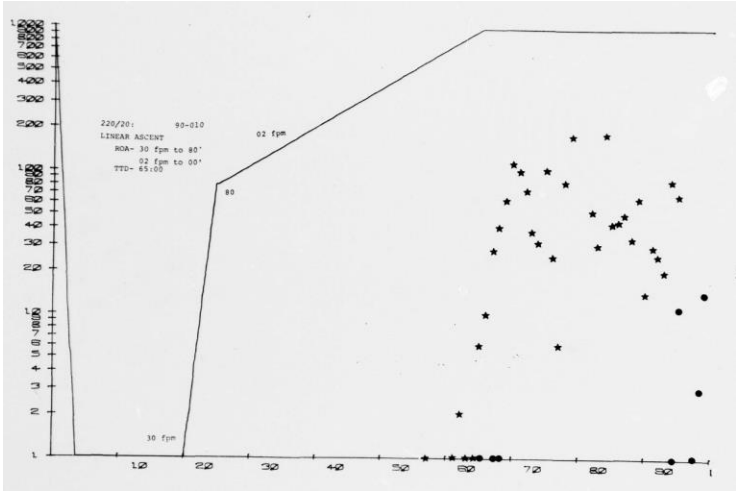
Gerth WA, Doolette DJ, Gault KA. Deep stops and their efficacy in decompression. In: Vann RD et al., editors. Technical diving conference proceedings. Divers Alert Network; 2009. p. 138-57.; Doolette DJ, Gerth WA, Gault KA. Redistribution of decompression stop time from shallow to deep stops increases incidence of decompression sickness in air decompression dives. 2011. NEDU TR 11-06

Real-Time Physiological Status / Real-Time Decompression









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Smith KH, Stayton L. Hyperbaric decompression by means of bubble detection. Final Report. Arlington (VA): Office of Naval Research (US); 1978.

Real-Time Decompression with VGE

- Wearable/submersible real-time VGE monitoring
- What pattern of VGE during the dive results in efficient decompression?
  - Short decompression / Low DCS incidence
  - Presumably mid-grade peak post-dive VGE

Future Research Summary

- DCS pathophysiology
  - Acute musculoskeletal pain
  - Spinal manifestations
  - VGE/extravascular bubble relationships
  - Day-to-day variability in VGE and DCS susceptibility
- VGE (or other physiological marker) during diving
  - Real-time decompression control
  - Probabilistic decompression model input
- Data collection
  - New, large-scale laboratory trials unlikely
  - Targeted field collection
    - Sensitive, specific marker for DCS
    - Wearable physiological monitoring