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Development of a Minimally-Invasive Blood Collection Device for Cetaceans

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WOODS HOLE OCEANOGRAPHIC INSTITUTION

Tasso

Office of Naval Research ONR Science & Technology

U.S. NAVY MARINE MAMMAL PROGRAM BIOSCIENCES DIVISION

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At-Risk Cetaceans

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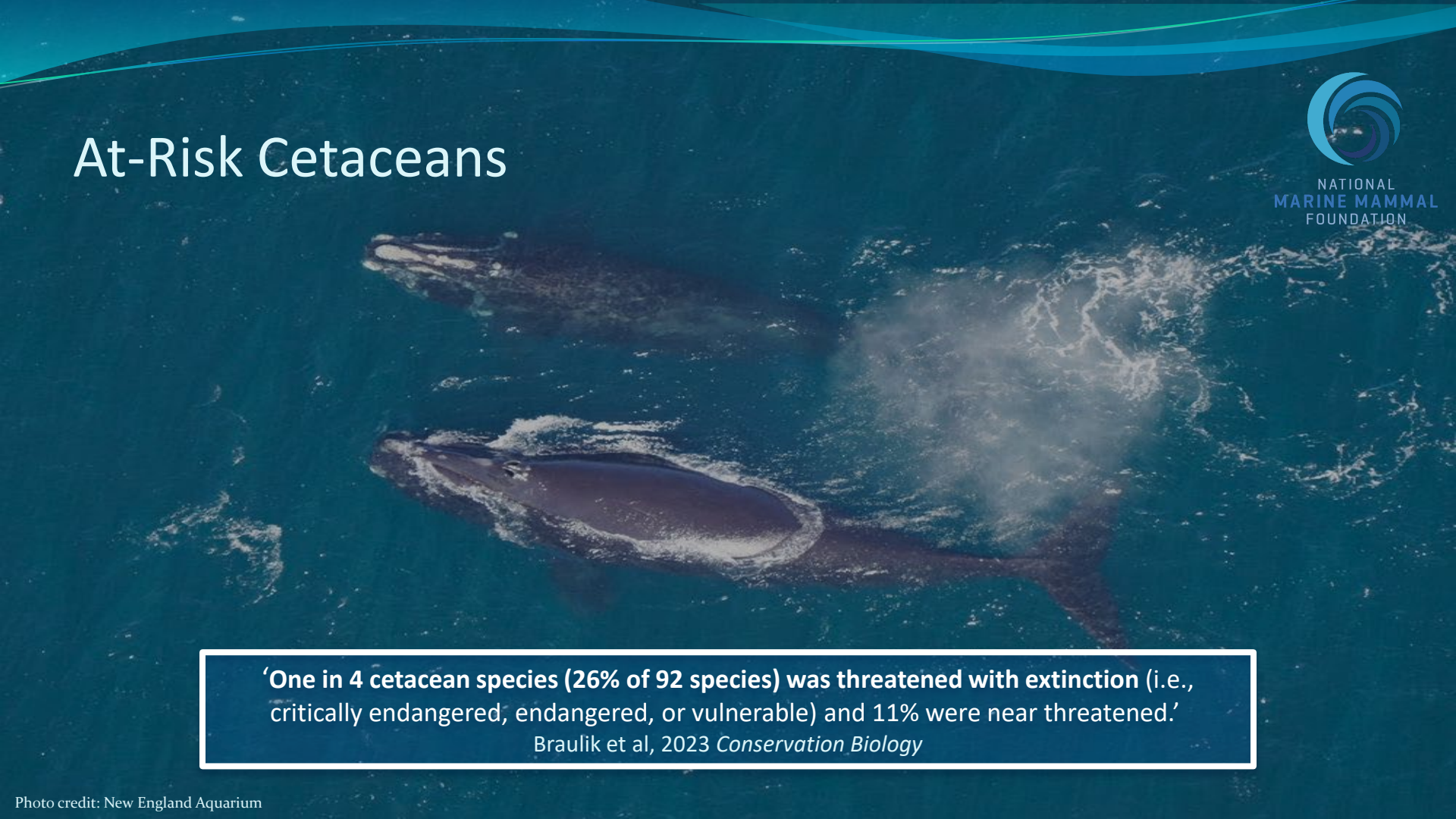

'One in 4 cetacean species (26% of 92 species) was threatened with extinction (i.e., critically endangered, endangered, or vulnerable) and 11% were near threatened.'

Braulik et al, 2023 *Conservation Biology*

Photo credit: New England Aquarium

Health Assessment & Monitoring

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Permit 18786-03

Health Assessment & Monitoring

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Photo: US Navy

Human Inspiration

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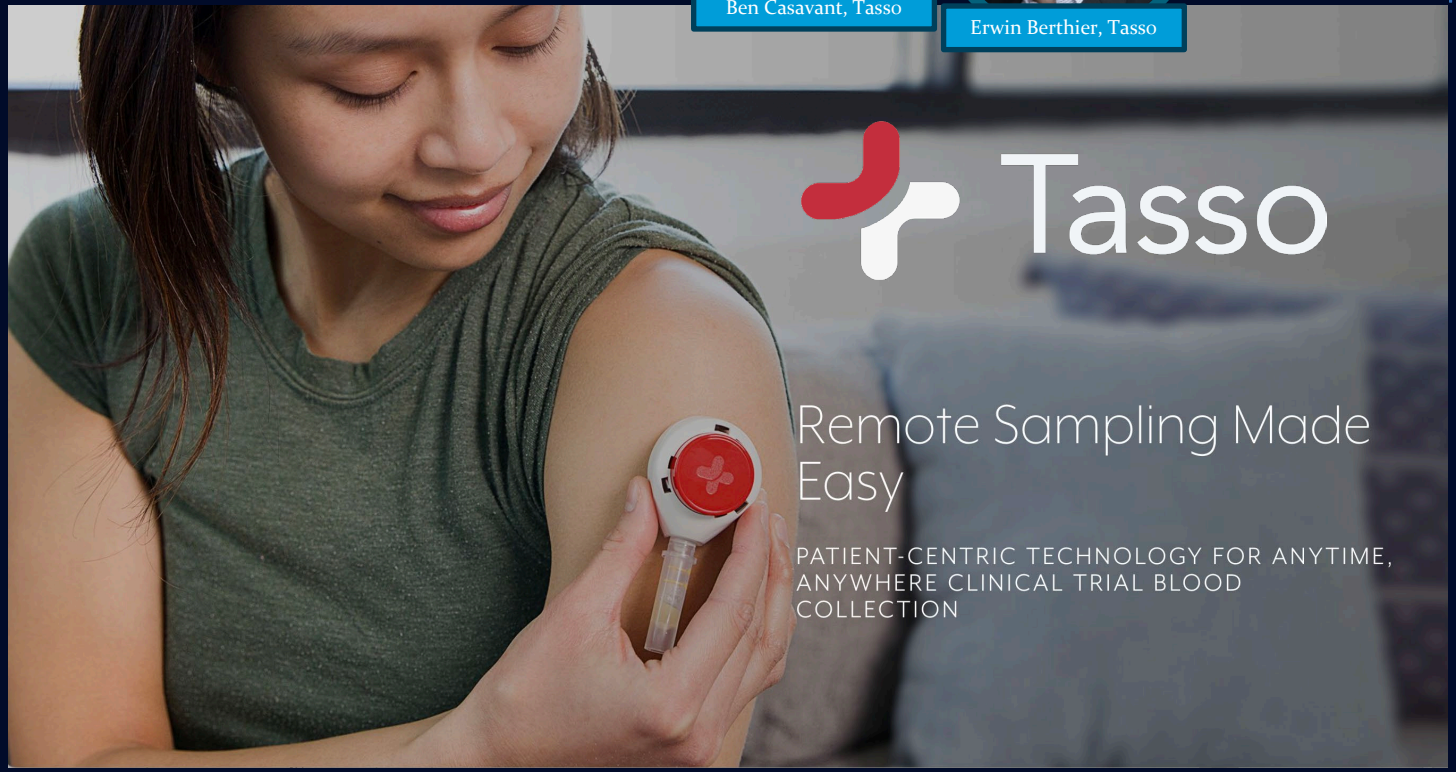

Easy Button for Cetaceans?

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ONR-Funded Project

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Develop a minimally-invasive blood collection device for dolphins, inspired by Tasso's HemoLink, with the *long-term goal* of developing a remote device capable of collecting blood from a broad-range of free-swimming cetaceans.

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Technical Approach

Translating Navy Medicine into Conservation Medicine

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Photo Credit: U.S. Navy

Primary Objectives

(1) Conduct an iterative sequence of testing and engineering modifications to Tasso's HemoLink™ device, with the goal of collecting 200-400 uL of blood from dolphins

Photo Credit: U.S. Navy

Photo Credit: U.S. Navy

Primary Objectives

(2) Compare blood analytes between blood collected with the prototype device and blood collected by routine venipuncture from the fluke periarterial venous rete (PAVR)

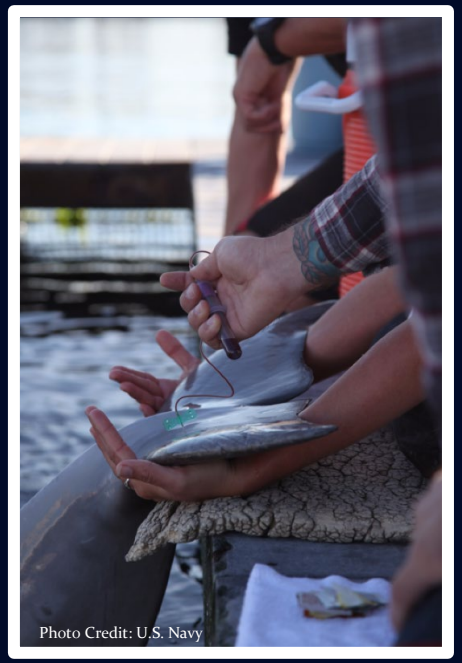

Photo Credit: U.S. Navy

Prototype Development

Adapt Device to Dolphins

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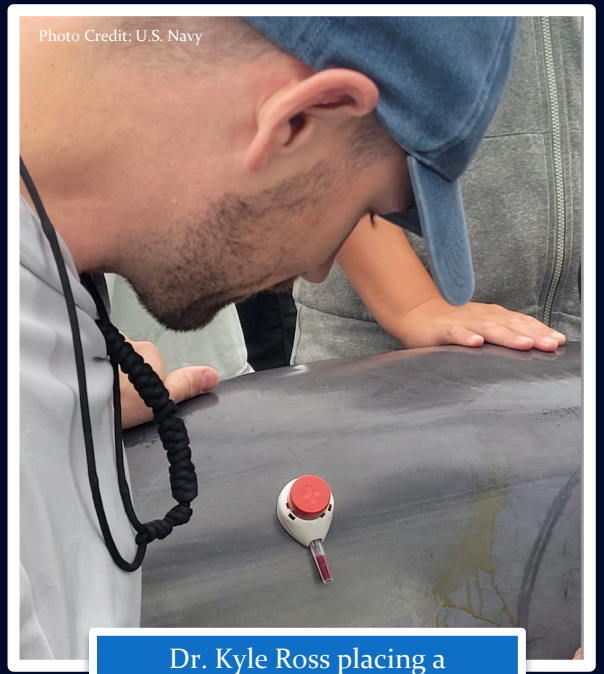
- 22 prototypes developed and tested
  - *Incision depth ranged from 1.5 to 5 mm, optimized to reach capillary beds*
  - *Varied anticoagulant placement and volume*
- FINAL PROTOTYPE = Hemotag
  - *5 mm incision depth (~width of grain of rice)*
  - *Both device and needle coated with anticoagulant*
- 136 total placements
  - *84 on Navy dolphins*
  - *52 on wild dolphins*
    - *44 in Barataria Bay, LA (Tursiops truncatus)*
    - *8 in Amana Reserve, Brazil (Inia geoffrensis)*

Photo Credit: U.S. Navy

Primary Challenges

- **Clots** *(anticoagulant, incision depth)*
- **Yield** *(depth, warmth)*



Dr. Kyle Ross placing a hemotag on a Navy *Tursiops*

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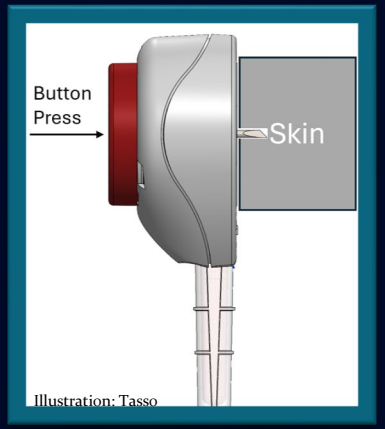
Photo Credit: U.S. Navy
Photo Credit: U.S. Navy

Final Device Configuration

- Device adheres to skin via pressure sensitive adhesive film
- Button is pressed, spring loaded lancet/blade (heparin coated) punctures skin and creates incision
- Button is released, blade retracts, and internal vacuum is created to help draw blood out of the incision
- Blood flows through microfluidic channel (LH coated) and into LH tube, assisted by gravity
- Device is peeled off skin, tube is twisted off device and capped



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Field Testing

Barataria Bay Bottlenose Dolphins

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ONR-NMMF Intern Candace Remo placing hemotag on wild *Tursiops*

NOAA Permit #24359

Field Testing

Amazon River Dolphins

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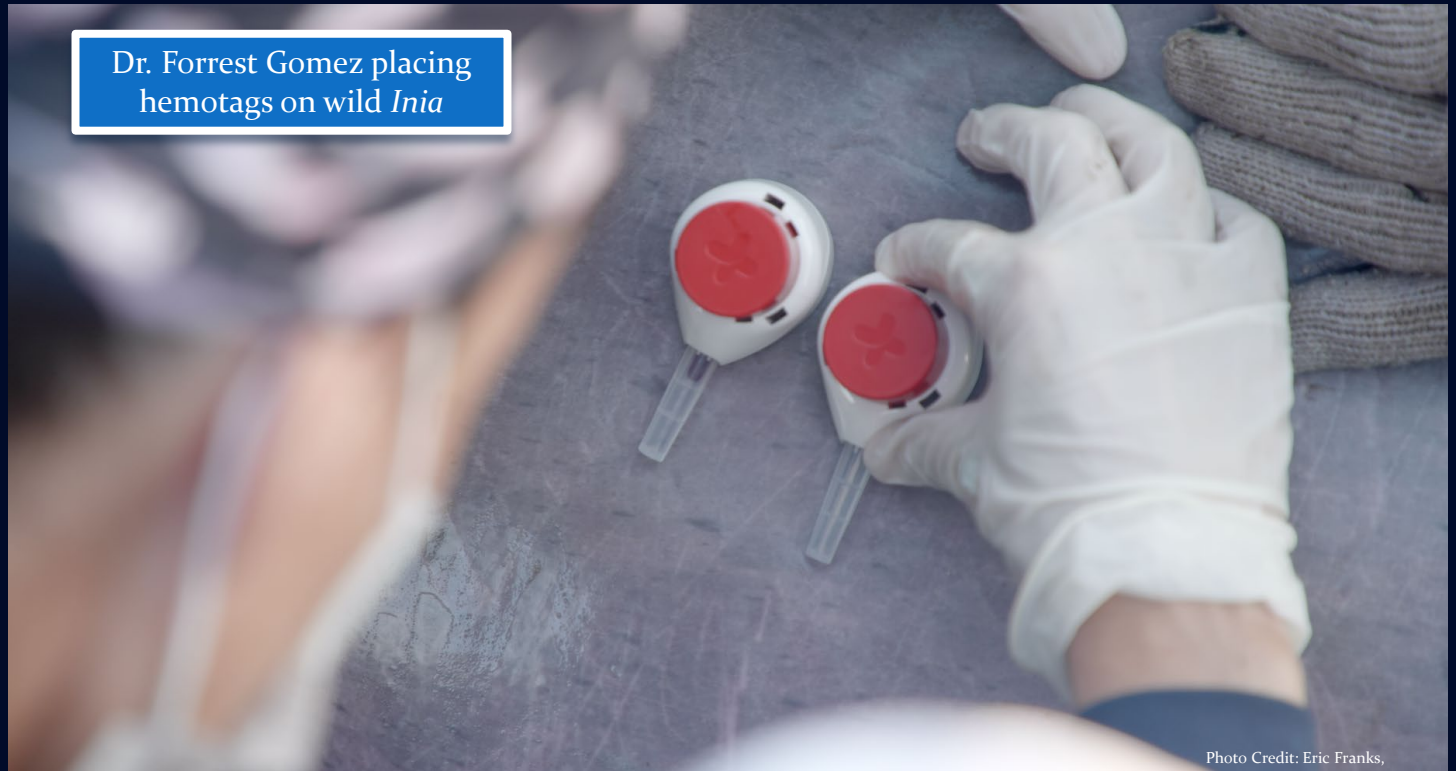

Dr. Forrest Gomez placing hemotags on wild *Inia*

Photo Credit: Eric Franks,

Primary Objectives

(2) Compare blood analytes between blood collected with the prototype device and blood collected by routine venipuncture from the fluke periarterial venous rete (PAVR)

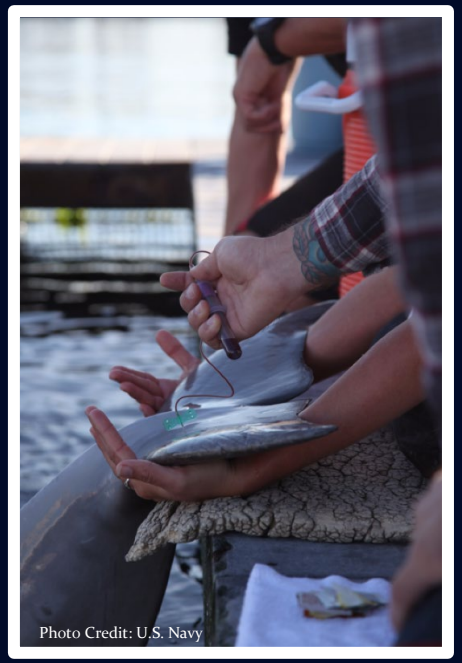

Photo Credit: U.S. Navy

Comparison Study

Prototype Blood vs PAVR Fluke Blood

29 Dolphins (Tursiops truncatus)

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Demographics/Morphometrics	Summary Statistics*
Sex	Female: 55% (n=16) Male: 45% (n=13)
Age (yrs)	21 (6 – 49)
Weight (kg)	187 (143 – 258)
Length (cm)	253.0 (217.5 – 275.0)
Blubber thickness (cm)	1.96 (1.29 – 2.94)

**Median age is provided with range. Weight, length, and blubber thickness are provided as means with ranges.*

Target Analytes: *PCV, Total Protein, Total WBC Count, Diff (Neutrophils, Lymphocytes, Monocytes, Eosinophils), Sodium, Potassium, Chloride, Ionized Calcium, TCO_2, Glucose, BUN, Creatinine*

Comparison Study Results

Prototype Capillary Blood vs PAVR Fluke Blood

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- Comparable: *PCV, TP, WBC, monocytes, eosinophils, glucose, creatinine*
- Not comparable: *neutrophils, lymphocytes, Na, K, Cl, iCA, TC02, BUN, Hb, AG*

Analyte	PAVR n	PAVR mean (CI)	Capillary n	Capillary mean (CI)	t-test p value	p < 0.05	Pearson's coeff	CCC	Deming int	Deming slope
PCV	29	39.8 (38.9-40.7)	29	39.8 (38.9-40.8)	0.921		0.715 (0.472-0.857)	0.712 (0.475-0.853)	-4.8 (-15.5-6)	1.1 (0.9-1.4)
TP	29	7.5 (7.4-7.6)	29	7.6 (7.4-7.7)	0.095		0.848 (0.698-0.926)	0.834 (0.68-0.917)	-0.1 (-1.4-1.2)	1 (0.9-1.2)
WBC	29	6.9 (6.2-7.6)	29	6.8 (6.1-7.5)	0.792		0.511 (0.177-0.739)	0.509 (0.183-0.734)	0.6 (-2.5-3.7)	0.9 (0.5-1.4)
NEUT	29	67.1 (63.5-70.7)	29	63.1 (59.8-66.5)	0.000	*	0.841 (0.685-0.923)	0.763 (0.581-0.872)	2.5 (-9.1-14)	0.9 (0.7-1.1)
LYMPH	29	17.5 (14.2-20.8)	29	20.2 (16.8-23.7)	0.000	*	0.919 (0.834-0.962)	0.876 (0.764-0.937)	2.1 (-1.8-5.9)	1 (0.8-1.3)
MONO	29	2.4 (1.7-3)	29	2.7 (2.1-3.4)	0.366		0.304 (-0.07-0.603)	0.298 (-0.062-0.59)	0.2 (-3.9-4.3)	1.1 (-0.9-3)
EOS	29	12.9 (11-14.9)	29	13.8 (11.9-15.7)	0.296		0.625 (0.336-0.807)	0.615 (0.332-0.796)	1.9 (-3.7-7.5)	0.9 (0.5-1.4)
Na	24	154 (153.4-154.7)	24	152.9 (152-153.7)	0.001	*	0.653 (0.34-0.836)	0.517 (0.236-0.718)	-79.1 (-215-56.9)	1.5 (0.6-2.4)
K	24	3.8 (3.7-3.9)	24	4.8 (4.5-5.2)	0.000	*	0.475 (0.089-0.737)	0.093 (0.006-0.178)	-20.8 (-46-4.3)	6.8 (0.1-13.5)
Cl	24	118.8 (117.9-119.7)	24	121.8 (120.6-123.1)	0.000	*	0.351 (-0.061-0.661)	0.196 (-0.04-0.412)	-167.6 (-442.6-107.4)	2.4 (0.1-4.7)
iCa	24	1.2 (1.2-1.2)	24	1.1 (1.1-1.2)	0.000	*	0.533 (0.165-0.771)	0.281 (0.065-0.471)	-2.6 (-4.5--0.8)	3.1 (1.6-4.7)
TCo2	24	26.8 (25.6-27.9)	23	22.6 (21.4-23.7)	0.000	*	0.515 (0.131-0.765)	0.227 (0.033-0.404)	-4.5 (-37.2-28.2)	1 (-0.2-2.3)
Glu	24	100.5 (93-107.9)	24	100.9 (93.4-108.4)	0.840		0.84 (0.661-0.929)	0.84 (0.666-0.927)	0 (-25.6-25.6)	1 (0.7-1.3)
BUN	24	65.8 (58.9-72.8)	24	62.9 (55.8-69.9)	0.005	*	0.961 (0.911-0.983)	0.945 (0.882-0.975)	-3.9 (-14.6-6.9)	1 (0.8-1.2)
Crea	24	1.5 (1.4-1.7)	24	1.5 (1.4-1.7)	0.575		0.976 (0.945-0.99)	0.971 (0.939-0.986)	-0.2 (-0.3-0)	1.1 (1-1.2)
Hb	24	12.2 (11.8-12.6)	24	12.7 (12.3-13.1)	0.000	*	0.825 (0.632-0.922)	0.718 (0.495-0.853)	0.3 (-4.8-5.5)	1 (0.6-1.4)
AG	24	13.1 (12.3-13.9)	23	14.3 (13.5-15.2)	0.032	*	0.23 (-0.202-0.586)	0.194 (-0.165-0.507)	2.7 (-18.9-24.3)	0.9 (-0.8-2.5)

Comparison Study Examples

PAVR Fluke Blood vs Capillary Blood from Hemotag

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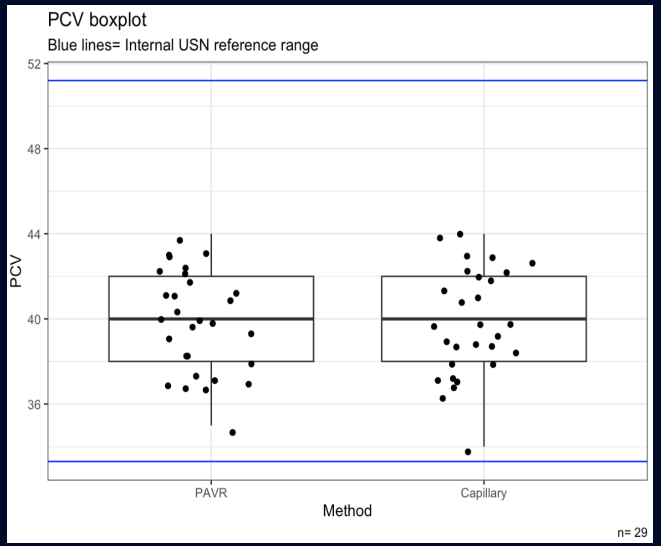
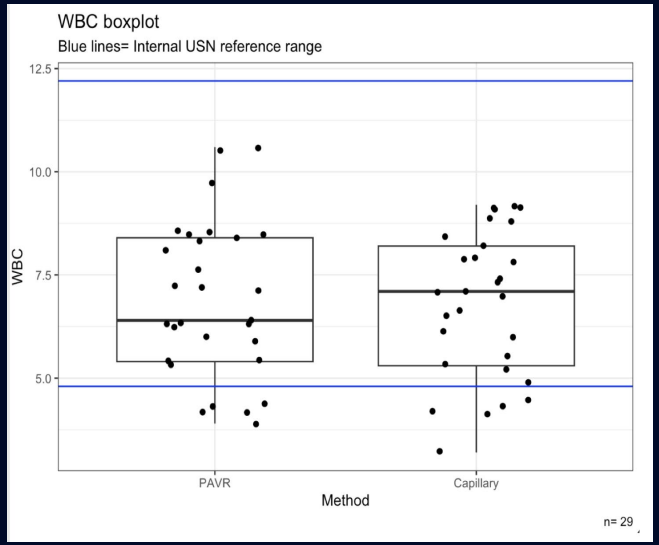
- Packed Cell Volume (PCV)



Traditional Hemotag

(Wilcoxon p= 0.76)

- Total White Blood Cells (WBC)



Traditional Hemotag

(Wilcoxon p= 0.34)

Overview

- Developed a minimally-invasive blood collection device prototype for cetaceans that reliably collects ~200uL capillary blood
- Comparison of capillary blood (from Hemotag) to PAVR fluke blood showed agreement for several clinically relevant values, including:
  - *PCV (p= 0.76)*
  - *Total WBC count (p= 0.34)*
  - *Total protein (p= 0.07)*
- Successful collection from two species
- Proposal for next phase of development, field testing, waterproofing, skin warming, and adaptation to whales is under review

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NMFS permit no. 18786
Photo Credit: U.S. Navy

Acknowledgments

Questions?

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ADDITIONAL SLIDES – MAY USED IF NEEDED

Accomplishments

Comparison Study: Prototype Blood vs PAVR Fluke Blood

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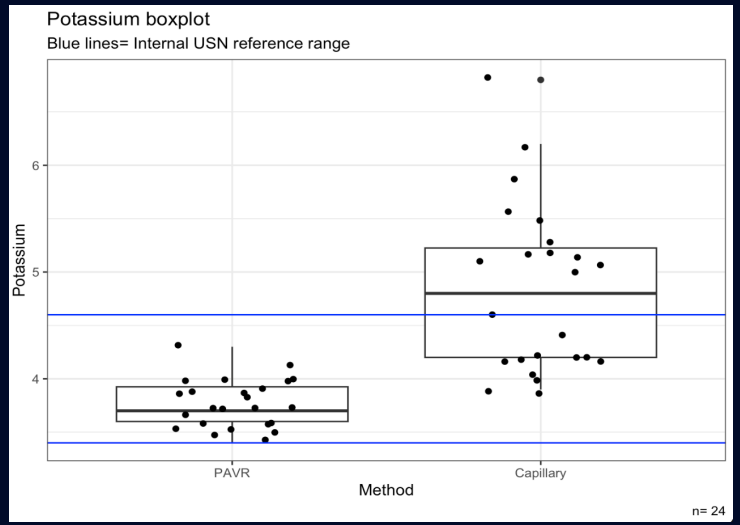
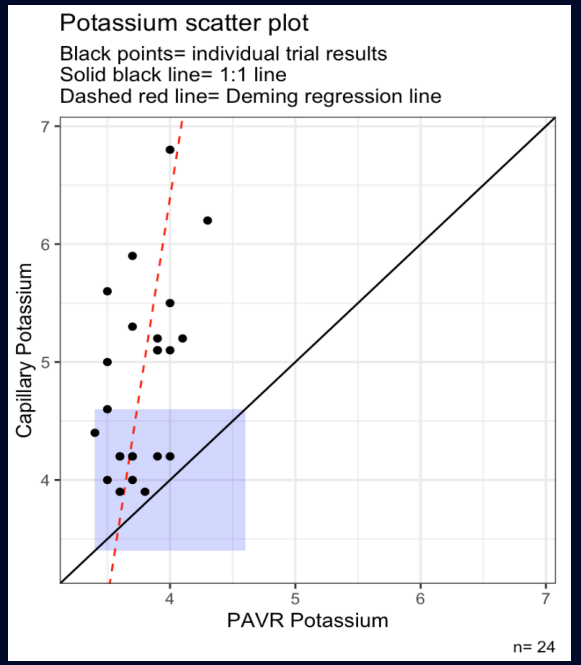
- Potassium



(Wilcoxon p= 0.000019)



Accomplishments

Comparison Study: Prototype Blood vs PAVR Fluke Blood

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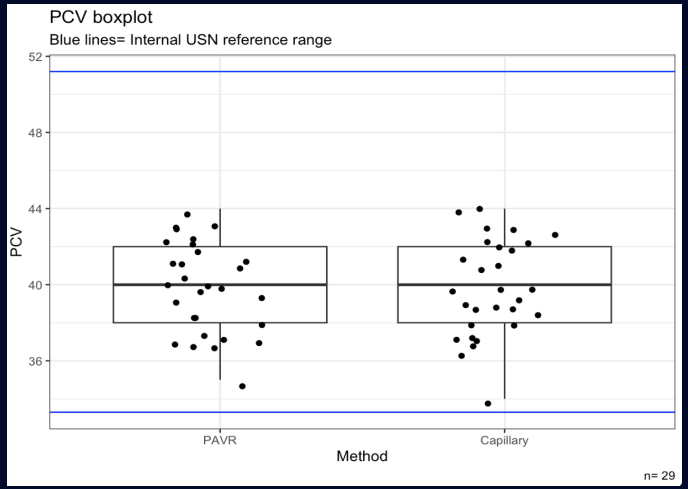
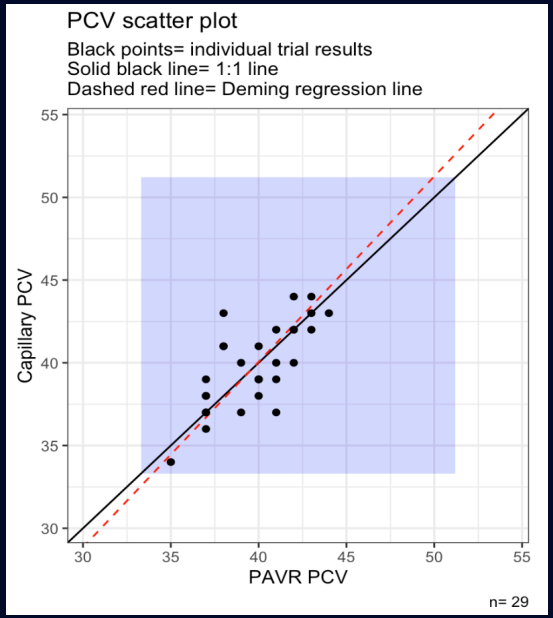
- PCV



(Wilcoxon p= 0.76)



Deming regression is an errors-in-variables model that fits a line describing the relationship between two variables. Unlike ordinary linear regression, it is suitable when there is measurement error in both variables.

Accomplishments

Comparison Study: Prototype Blood vs PAVR Fluke Blood

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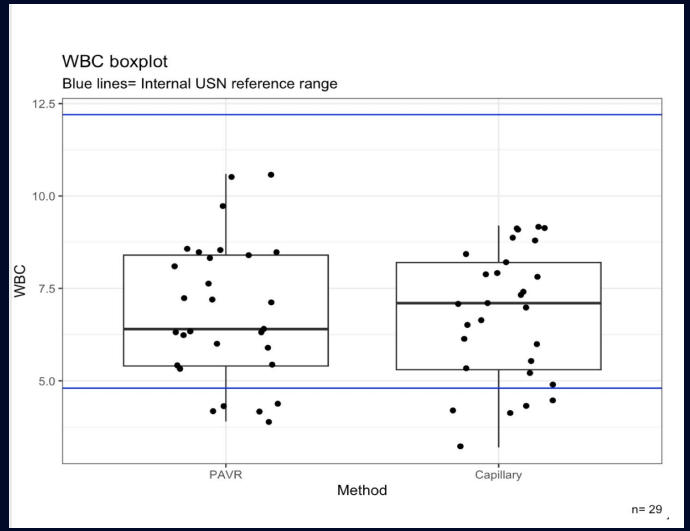
- Total WBC



(Wilcoxon p= 0.34)