The History of Buoyancy Compensators

Deflating Some Myths…

An interpretive review of the evolution of buoyancy compensation in SCUBA diving with specific regard to the USA.

Warning – Academics beware! This is for entertainment purposes only…Facts and truth as aspirations of this presentation. Some “facts” are interpreted or flat out ignored for humorous effect and some names are changed to protect the guilty… This takes a strong US perspective to entertain and make a boring topic interesting for the audience only…29 Calories from Fat.
What is a Buoyancy Compensator?

Device attached to a divers body able to retain and vary an amount of air in order to affect the overall buoyancy of the diver in water and compensate for changes in buoyancy that occur in the other pieces of the divers system.

Myth Deflated!
Jacques Cousteau did NOT invent the SCUBA buoyancy compensator…
Our Timeline

• **BCou (Before Cousteau)** – 700 BC 1943ish
  – Ancient
    • Assyrian Seal Teams
  – Archaic
    • Archimedes, Da Vinci,
    • Hard Hats

• **ADu (After Dumas)** – 1950
  – Vintage: (SeaHunt Era) 1947 - 1966
  – Contemporary: 1984 – Today
  – Jetson: The Future
722 – 705 BC: Assyrian Seal Teams

• In reaction to an indefensible location, Assyria creates a strong army under Sargon II
• Metal armament equipped SEAL teams
• Used breathing bags (perhaps) made from airtight goatskins

Myth Deflated!
The Assyrians did not invent Sink the Stink
3rd Century BC - Archimedes the Greek P.I.

Archimedes Law:
An immersed object is buoyed up by a force (the **Buoyant force**) equal to the weight of the water it displaces.
1500’s – Leonardo lung Designed

- Leonardo da Vinci designs the first known SCUBA in the Codex Atlanticus
- Combined surface air supply and buoyancy control
- Leveraged leather extensively in the design of a watertight drysuit with glass goggles and hand fins

Myth Deflated!
Cave divers did not design the P-Valve...
Da Vinci’s drawings were so detailed we can confirm that he invented it!

Myth Deflated!
This was never built, but was abandoned in favor of the diving bell...
1810 - Hall’s Diving Suit

- Patented
- Took the term “Dry Suit” literally
- Proposed layered materials of rubberized fabrics
- May have invented the overpressure valve
- Design actually used

Myth Deflated!
While reinforcing is evident throughout Hall’s suit...
There is no truth to the rumor that Hall’s suit was for early shark diving tourism
1823 – Macintosh Waterproof Fabric

- Rubber dissolved in Coal Tar (Naptha)
- Patented the first rubber/fabric sandwich
- Allowed the creation of the full diving dress for Deane Brothers / Siebe closed diving dress
- 1839 - further enhanced with the vulcanization process (Charles Goodyear)

Myth Deflated!
Macintosh didn’t set out to develop the raincoat because he lived in Scotland, he was just trying to find uses for Coal waste products!

His work enabled Siebe’s full diving dress with a vulcanized/canvas dry suit
1828 – Paul Lemaire d' Augerville’s BC

- Not much is known about his system
- Decided to innovate over the common practice of using diving bells for salvage
- Patented a diving system with weights, an integrated buoyancy compensator that weighed over 100 lbs...
- Was used for a few years but faded into obscurity with the advent of the Siebe and Dean systems...
- May have invented the Advanced Design Buoyancy Compensator...
- bookmarks

 Myth Deflated!

This genius inventor wasn’t an engineer he was actually a Parisian Dentist with offices on the same street as Cousteau’s (Ave. St. Honore)

<<Watch out for SCUBA dentists>>
1837 Siebe’s Hardhat and dress

- Based on smoke hats and prior systems developed by the Deane Brothers with partial dress gear
  - Self Rescue was required by the Deane Brothers
- 1819 Siebe create open dress helmet and jacket
- 1837 Combined dress and helmet
- Allowed buoyancy variation/equalization through simple valves

Myth Deflated!

Walking on the bottom wasn’t all that it was cracked up to be...

Surface supplied divers used buoyancy compensation and self flotation in the 1830’s!
1950 – Dumas’ SCUBA compensator

- Arguably deserves “First BC” Title
- Dumas
  - Taught Cousteau to dive
  - Was a spearfisherman
  - Was the deep diver in the group
  - Was a self taught engineer
- Controversy over the design
  - Described as a Horsecollar
  - Stayed on the diver
- Functioned as a rescue device
  - Oral Inflator
  - Air Supply

Myth Deflated!
While Dumas was known for his humor...
He did not invent the whoopee cushion!
1950s- Diving Captures our Imagination

• Small numbers of Aqualungs disperse into the world...
• Scientists and military divers rapidly respond
• The underwater world becomes “open” to the adventurous
• Training starts
1951 Wetsuits are invented

- The Navy requests a swimmers suit
- Hugh Bradner has a free weekend
- Willard Bascom suggests Rubatex Neoprene
  - Sold as rug padding in aircraft
- 1953 Engineers at UC Berkeley form EDCO
- Documented in Scripps Institute files
- Buoyancy Swing for a diver increases by 10+lbs...

Myth Deflated!
The wetsuit was not necessarily invented by Hugh Bradner.
The Santa Ana Sentinel records Art Brown of Laguna make wetsuits in April 1950...

Bascom

Bradner
1950’s Mae West and self-rescue

- Driving needs
  - Self Rescue
  - Swimming
- Surplus/ Mae West Vests
- Res-Q-Pak
- FLOOTO
  - Sausage
Res-Q-Pak in action

From Skin and Scuba Diving – 1961 by Gustav Della Valle

Myth Deflated!
The Res-Q-Pak did not spawn the hoppity-hop ball craze of the 1960’s
Scripps Scientists start diving...

- First formal non-military training program for SCUBA
  - Training in proper weighting
  - No buoyancy compensation training
  - Significant Physical Training
  - Made Scripps Canyon diving a challenge...
- Set precedence for all academic diving
1958 Sea Hunt Creates a market

- SCUBA was essentially 8 years old in the USA
- Popularized and created the market for SCUBA
- Set the stage for Certification

“It was the first time anyone tackled a show that took place underwater. The stories were sort of exciting for kids, like cops and robbers underwater.”

Myth Deflated!

Lloyd Bridges was not hired for his diving ability…His first SCUBA lesson was during the first episode shoot, from his stunt double Courtney Brown.
A generation is engaged

- Media Blizzard
  - SeaHunt
  - Cousteau’s films
  - National Geographic
  - Thunderball
- Certification Agencies started
  - LA County 1954
  - YMCA 1950
  - NAUI 1960
  - PADI 1966

Someday... I am gonna redesign this mask...

I look just like Dustin Hoffman in The Graduate...
1960s – Lifevests and self rescue

• First Cataloged 1958 U.S. Divers catalog
• Surface Flotation, Self Rescue
  – Small oral inflators
  – CO₂ Inflation
  – SCUBA specific
  – Crotch Straps
• Construction
  – Hand Glued nylon/neoprene Construction
  – RF Welded Nylon/PU (quality problems)
Where did the parts come from?

- Supplied inflator valves
- CO$_2$ Manifolds
- Oral Inflator valves
- CO$_2$ cartridges from Sparkletts
1961 Fenzy Frenzy

- First commercially successful “Modern” Buoyancy Compensator
- Invented by the Underwater Research Group of the French Navy
  - Self-Rescue device
- 1968ish appeared in numbers in the US market
Fenzy-lution and the ABLJ

- Breathable Valves
- Shoulder dump valves
- Single Bag 3-D Design
- Super-tough Construction
Mid-Vintage Era – US “Compensators”

- Oral inflation hoses properly positioned
- Overpressure valves
- Construction Innovations
  - “Double Bag” Nylon bag with Nylon/PU
  - Radio Frequency Welded construction
- Lagged European development
Automatic Buoyancy Life Jackets

- European Solution
  - Early Adopter of Self Rescue
    - Club driven training
    - Safety focused
  - Breathing bag concept familiar to military \( \text{O}_2 \) Rebreather teams
  - Market was far advanced in UK, France through 1960’s
1970’s Styles...

- True Buoyancy Compensators in the US market
  - Inflation and deflation at depth
  - Over Pressure valves

- Jacket Styles
  - Scubapro Stab Jacket
  - Soniform OEMs BCs
  - Seatec Innovates

- Back Inflation
  - Watergill Stuns

- Large volume Horse Collars
  - US Divers
  - Scubapro
  - Nemrod
  - Seatec
  - Soniform (various brands)

- Hardshells
US catches up...

- Fenzy
- Nemrod
- Scubapro
- Mares
- Cressi-sub

Automatic Safety Vest?
1971 – Scubapro Stab Jacket

- Patented 360 degree flow through design
- Neoprene coated fabric
- Labor intensive (!) hand manufactured
- Designed by a dentist?
  - Valve placement…

Ancient  Archaic  Vintage  Classic
Power Inflators

- 1968 Fenzy BC systems with large diameter hoses and “breathable” oral inflators appear in the US
- 1969 Greenwood Patent issued
- 1971 Scubapro Power Inflator released
- 1975 Seatec, Soniform set standard for quick disconnect
- 1983ish Apollo Schrader valve inflator designed
~1979 AIR II Breathable Inflator

- 1978 Scubapro patented design
1973 – US Divers BC II

- Power inflator
  - Bypassed Greenwood Patent
  - Right side inflator
- Oral Inflator
- Top Dump with Overpressure valve
- Double Bag with PU bladder
Focus: Techniques and Materials

- Radio Frequency (RF) Welding
  - 25 – 50 KW
- Blown Polyurethane (PU) film
- Fabric/PU laminates
- Offshore tooling, production

Myth Deflated!
Contrary to popular belief...
Buoyancy Compensators aren’t sonically welded!
1971 – 1986 Jackets

- Bypassed Stab Patent
  - Split underarm
- Lifted diver from under arms
- Integrated backpack
  - Used standard back pack/straps
- Soft Pack Developed
  - Seatec Manta
1972 – The Watergill At Pac

- Watergill Manufacturing
- List of firsts
  - Wings
  - System BC
  - Weight Integrated
  - Shell System
  - Cummerbund

Capt. Chad Carney – early ’70s
The At-Pac was ahead of its time...
Politics, Marketing, and Success

- Sold through select dive shops
  - Tied closely to NASDS instruction
- Watergill – Seapro ownership transition
- Campaign to discredit the BC
- Lifesaving need still present
  - “Float ya face down and kill ya…”
  - “Ya can’t dump the air…”
  - “Ya can’t dump the weight…”
1970’s – 1980’s WINGS

• Everyone else made wings…
  – Scubapro BCD
  – Seatec
  – SeaQuest
  – Soniiform
  – Zeagle
Shrouds and Shells

UDS-1 SYSTEM
ALOHA ADVENTURE! THE ALL-IN-ONE SYSTEM!

NEW EXCLUSIVE U.S. DIVER SAFETY / SATISFACTION GUARANTEED

The innovative UDS-1 System offers a new and improved design for SCUBA, Snorkeling, and Freediving. The system includes a lightweight, comfortable harness and a versatile regulator that attaches to the harness, providing a secure and adjustable fit. The regulator is equipped with a quick-release mechanism, allowing for easy repositioning and adjustment. The system is also designed to be compatible with a wide range of diving equipment, including fins, masks, and wetsuits. Whether you are a casual diver or an experienced snorkeler, the UDS-1 System is the perfect choice for your underwater adventures.
1976ish..Dacor Nautilus

- Fixed volume
  - Regulator/inflator maintained volume
- Automatic buoyancy
- Conceptually flawed
  - Due to variable buoyancy of the wetsuit and tank
April 1985 - Advanced Design Vest

- Shoulder adjustable
- Replaced the jacket style
- Wasn’t Patented
- Continues to be produced by most manufacturers
- “Moved” the backpack
- Remains in favor today

Myth Deflated!
Seaquest often hired talent for ads, but...

The Darkhaired guy is Don Rockwell, President of Aqualung and SeaQuest...
1980’s Comfort Features!

• Cummerbunds
  – At-Pac inspired
  – No more webbing

• Separated Bladder from waist strap

• Releasing Shoulders

• Six sizes
1980’s Comfort on land...

• Softpacks
• Backpacking Technology
  – Shore diving needs
• Quick Release Shoulders
• Sizes, Colors
Focus: Designs and Engineering

- Independent engineering: John Ratliff – Parasea
- Lee Somers – Michigan Sea Grant
- Steve Paulette – URI
  - Low Drag, High Thrust, The check is in the mail…
- Jim Middleton – USN NEDU
- Jon Hardy – Scubalab
- NASA WETF
- PADI, NAUI
Focus: Military

- 1950’s – Swimmers Vests
  - Antimagnetic Requirements
- 1980’s – EDU Approves some commercial BCs
  - Need to remain with Diver negates jackets, wings
- 1990’s – Approves (ANU) many Commercial BCs

Non-Magnetic Swimmers Vest
Navy Seal Museum
Focus: PATA (Pink and Tiny with an A)

- **1960’s** – Wow – that’s a woman diver!
  - Zale Perry is the First Woman of Diving
  - The horsecollar doesn’t come in pink, but it fits
- **1970’s** – Women’s “Fitness to dive” challenged
  - Donna Tobias applies to the Navy’s dive school
  - Make the BC in an XS and an S size
- **1980’s** – Consider women’s needs in sizing, comfort, style
  - Make the XS, S, M, L in Pink
  - BCs can look fashionable
  - BCs can be more comfortable for women and men
- **1990’s** – Vocal demand from a large, knowledgeable group
  - BC models designed by women, for women, tested by women
  - W.E.T.T. Women’s Equipment Test Team
- **2000** – Necessity to fit a range of body shapes and sizes
  - Design for 40% of the market with a range of models
  - Large opportunities for improvement remain!
  - Offer functional styles for different types of diving
  - Tech / DIR – Make the XS backplate (in pink)
  - Scubawomen.org
1990s: Travel/ Low Volume BCs

- Started with the At-Pac
  - Retractable bladder
- SeaQuest Explorer (1992ish)
  - Jacket Style low volume
  - Bill Oliver Influenced thinking
  - Better buoyancy training developed
- USD Calypso
- Sherwood Destiny 30
- Zeagle BCs
1990s - Systems BCs take off

- At Pac started it…
- CUDA Systems – not pictured
- Zeagle Systems
- Sherwood Destiny (Soniform)
- DiveRite Transpac
- Plate/Pac combinations

Ancient  Archaic  Vintage  Classic  Contemporary  Future
1979 - Backplates

- Invented by cave diver Greg Flanagan during the first NSS/CDS cave training course held by Scheck Exley…
- Made from an aluminum road sign

Myth Deflated!
Contrary to popular belief, it wasn't invented as the result of a forklift running over a sheet of aluminum.

However... The outer plate from a Scubapro Stab Jacket was used as a pattern!
Focus: Weight Integration

- 1972 At-Pac
- 1975ish Scubapro
- 1989 Zeagle
- 1995 Weight Pocket Systems
Living the Dream – The Future?
Everything old is new again…

• Streamlining
  – Back inflation
• Less and More
  – DIR 2.0
• Electronics
  – Sense, Control
• Tuned weighting
  – Training and Knowledge
• Fit Fit Fit Fit Fit
  – Materials
  – Experienced design
• Wings for dogs?
Stuff I missed

• Back Packs
• Rebreather BCs
• Electronics
• HOW BCs work
• HOW to tune your buoyancy
• What you need to look for in a BC
• DIR systems
• Really Controversial topics
  – Tank Counterweights
  – Recalls
  – Production outsourcing
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- Harry Averill
- Don Rockwell
- Capt. Chad Carney
- Scubaboard.com
- Historical Diving Society
- Divinghistory.com
- Going Under Dive Center, Minnesota
- Steve Hornsby - Underwater Sports, Kirkland
- Scubapro, Aqualung/SeaQuest. Mares/Dacor, DUI
- The US Navy, Seal Team Museum, EDU facilities
- NASA WETF Facility
- DEMA
Myth Deflated!
Contrary to popular belief...
Buoyancy Compensator design
does not rely on animal testing!
THANK YOU!

David McLean
January 2006
Appendix
Links

• Assyrian perspective
  – http://www.adventurediveandsnorkel.com/id51.htm
  – http://timeline-of-underwater-technology.ignaut.net/
Diver Model
David McLean Bio...

- **Dive History**
  - 1970ish Certified NAUI Junior Scuba Diver - used a double hose reg. in class!
  - 1976 Research Diver Certified Scripps Institute of Oceanography (they swear they will never certify someone that young again.)
  - 1979 Naui (5675 retired) / PADI (forgot the #) Instructor certified – retired
  - 1981 President UCSD Dive Club
  - 1980 - 85 Divemaster for Scripps Aquarium Collecting Expeditions
  - 1989ish American Academy of Underwater Sciences (AAUS) Founding Member
  - NACD Basic Cave Trained (Jarrod Jablonski)
  - Undergrad Degree from UCSD in Marine Archaeology (Oceanography, Anthropology, Engineering plus five years at Scripps Institute in Physical Oceanography)
  - Diving Experience - 2300 hours underwater.
  - Travel - Been diving a bunch of interesting places all over the world, most everywhere EXCEPT Micronesia, where my nephew lives. He won't let me forget it. You would think I would go someplace where I could stay for free...

- **Professional Life:**
  - 1982ish started at Underwater Kinetics, then moved to a small company run out of two garages called SeaQuest as an Engineer, designed BCs for seven years, including the ADV Spectrum style.
  - Recruited to launch MARES in the USA through HEAD sports as Product Manager (a dive company in Colorado? You have got to be kidding!), then Sales Manager for Florida.
  - Director of Sales and Marketing at Soniform - we made about 30% of the BCs for the world. I started three brands for them that were very popular (perhaps too popular) internationally, but not sold in the US.
  - We were purchased by Scubapro in 1987 and we moved Scubapro out to San Diego to a facility we built, so we "became" Scubapro. I finished up my career as Product Manager of Scubapro in 1989.
  - <Big gap where I moved into technology, networking, Software Development, Dot-Com startups>
  - Currently I work at Microsoft as a Product Manager doing HR Technology and staffing systems strategy. I am sure you clearly see the fit of this with everything else I have done.