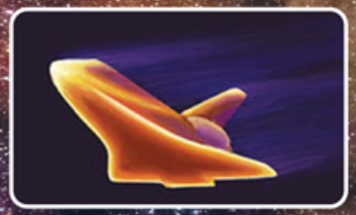
Autonomous Profiling Explorer – APEX

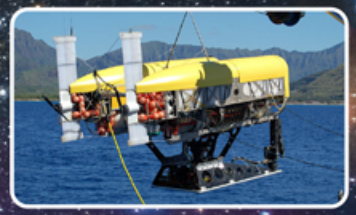
2017

From Deep Space to the Deep Ocean

Teledyne has Proven Solutions

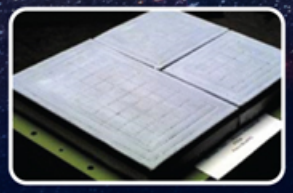
Over 50 years of experience taking on the world's most challenging environments

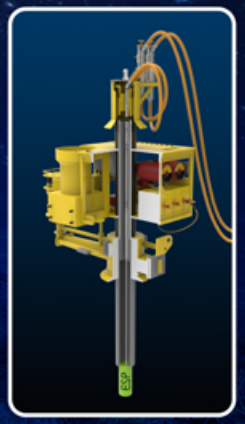




THE CHALLENGES

DEEP SPACE	DEEP WATER
Extreme Temperatures	Extreme Temperatures/Pressures
Long Lifetime	Long Lifetime
Repair is Not an Option	Repair is Impractical
Corrosive Conditions	Corrosive Conditions
Structural Load	Structural Load
Process Chain Traceability	Process Chain Traceability





IMAGING • INSTRUMENTS • INTERCONNECT • SEISMIC • VEHICLES

TELEDYNE MARINE
Everywhereyoulook

Teledyne Technologies' Unique Resources

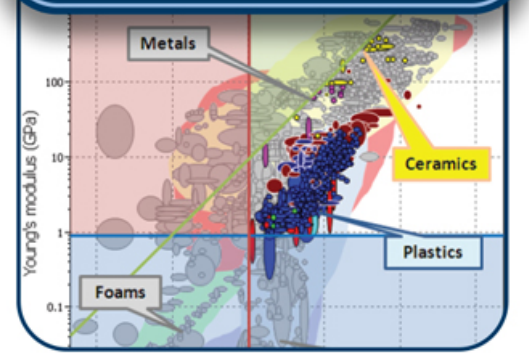
SCIENTIFIC RESEARCH ► PHYSICS / MATERIALS ► ANALYSIS, DESIGN, TESTING ► ENGINEERED SOLUTIONS

TELEDYNE SCIENTIFIC

Teledyne's advanced Materials Science and Research Center is staffed with technical experts and PhD-level scientists to solve complex challenges

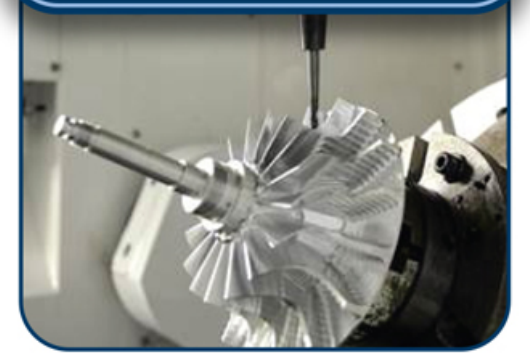
TELEDYNE MARINE

Technology Development Center focuses on new product development using high-reliability practices focused on testing to failure in an ocean simulation facility



TELEDYNE BROWN

Systems engineering, testing, and advanced manufacturing and Program Management capabilities to produce full life-cycle solutions



IMAGING • INSTRUMENTS • INTERCONNECT • SEISMIC • VEHICLES

TELEDYNE MARINE
Everywhereyoulook™


INTERCONNECT
AG Geophysical
DGO • Impulse • ODI
Storm Cable
VariSystems
IMAGING
BlueView • Bowtech
CARIS • Odom Hydrographic
RESON
TELEDYNE MARINE
Everywhereyoulook™
INSTRUMENTS
Benthos • CDL
Cormon • Oceanscience
RD Instruments • TSS
SEISMIC
AG Geophysical • Bolt
Geophysical Instruments • Real Time Systems
VEHICLES
Benthos • Gavia
Oceanscience • SeaBotix
Webb Research

TELEDYNE MARINE SYSTEMS
Everywhereyoulook™

At Teledyne Marine Systems, we strive to provide the marine community reliable systems to explore and characterize the ocean so that our customers may better understand how the ocean affects their businesses, their research, their security, and their life.

Our product offerings includes:

- Low logistics, high performance unmanned marine vehicles
- Sensor agnostic towed systems
- Undersea positioning and telemetry
- Deep sea infrastructure

Webb Research * Benthos * Gavia

Teledyne Marine Systems:

Teledyne Webb Research

Founded:
1982; acquired by Teledyne in 2008

Employees: 173 (shared with Benthos, TapTone, and Webb Research)

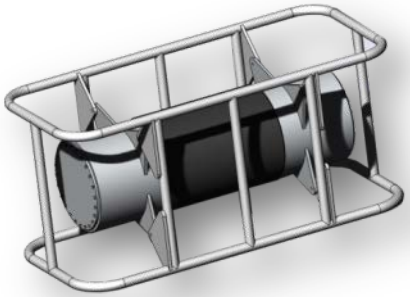
Locations:

- Main Office: North Falmouth, MA, USA

Products:

Premium supplier of:

- Autonomous Undersea Gliders
- Autonomous Profiling Floats
- Sound Sources

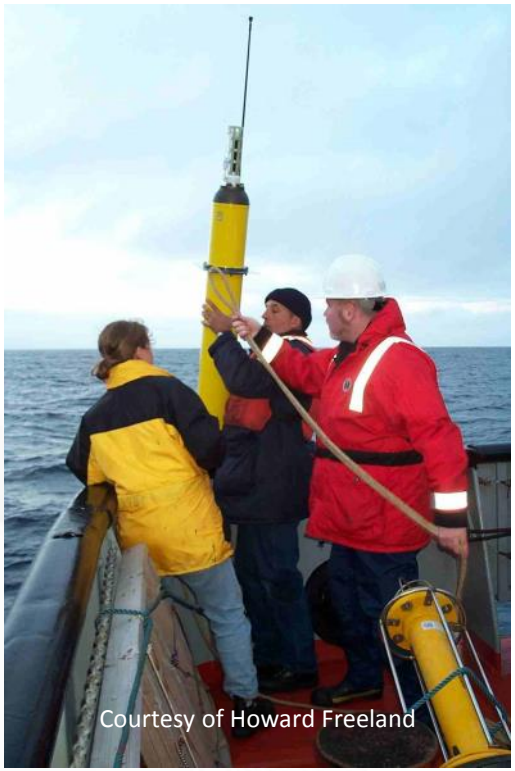


Autonomous Profiling Explorer – APEX

- SBE 41 and RBRargo CTD Options
- Iridium and Argos Telemetry Options
  - Efficient Compressed Binary Message Formats and Z-modem with Iridium
  - GPS positioning with Iridium
- Lithium and Alkaline Battery Options
- Ice Detection and Avoidance

APF-11 Controller

APF-9 Has Reached End-of-life
Board Level Components
No Longer Available


Courtesy of Howard Freeland

APF-11 Leverages Advances in Hardware and Components

- CTD, Optode and 8 Sensor Ports
  – Independent Sensor Control
- Compressed Binary Data & Z-modem
- Coulomb Counter
- Increased Memory
  – Can Store Lifetime of Data
- Increased Processor Speed
- Micrium OS for Low Level Infrastructure

TWR Intends a Stable APF-11 Controller Configuration Through 2025

APEX – BGC
Biogeochemical

SBE 41CP
or SBE 41N with SeaFET™
or RBRargo

2000 dbar Aluminum Hull

Lithium Batteries

Iridium CS/RUDICS and GPS

AADI 4330 or RINKO ARO-FT

WET Labs FLbb or FLbbCD

Multiple Ascents per Day

APEX with SBE-41N & SeaFET™

First Purchase by
National Oceanography Centre

End Cap Design with SBE

Coordination with Dana Swift (UW)

Extensive In-House Testing

In-Water Tests at MBARI
18-22 May, 2017

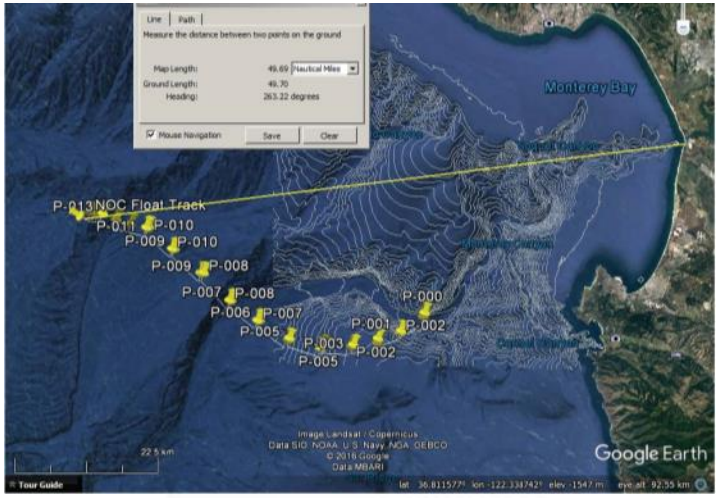
Courtesy of Ken Johnson

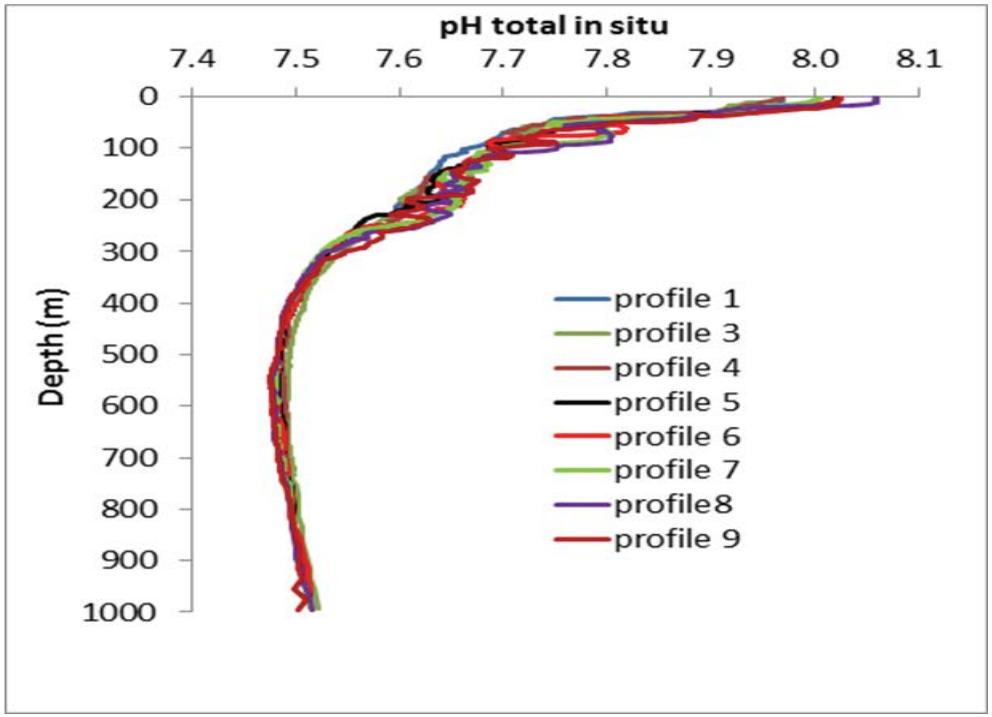
APEX with SBE-41N & SeaFET™

Initial Profiles to 300 m

Subsequent Profiles to 1000 m

Data Look “Very Good”





Images Courtesy of MBARI/NOC

APEX – AMS
Advanced Multi-Sensor

SBE 41CP
or SBE 41N with SeaFET™
or RBRargo

Patented 2000 dbar Composite Hull
Lower Weight, Greater Endurance

Lithium Batteries

Iridium CS/RUDICS and GPS

AADI 4330 or RINKO ARO-FT

Sensor Integration Rings
Up to 4 Sensors Each

- Satlantic OCR-504 ICSW
- Satlantic OCR-504 R10W
- Satlantic SUNA
- TNT Compass
- WET Labs C-Rover
- WET Labs ECO sensors

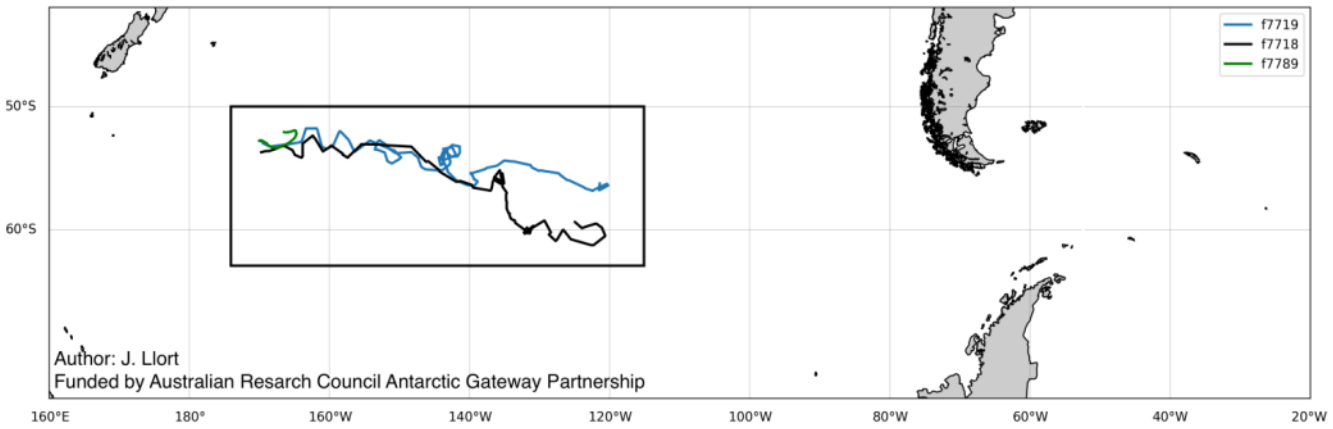
Multiple Ascents per Day

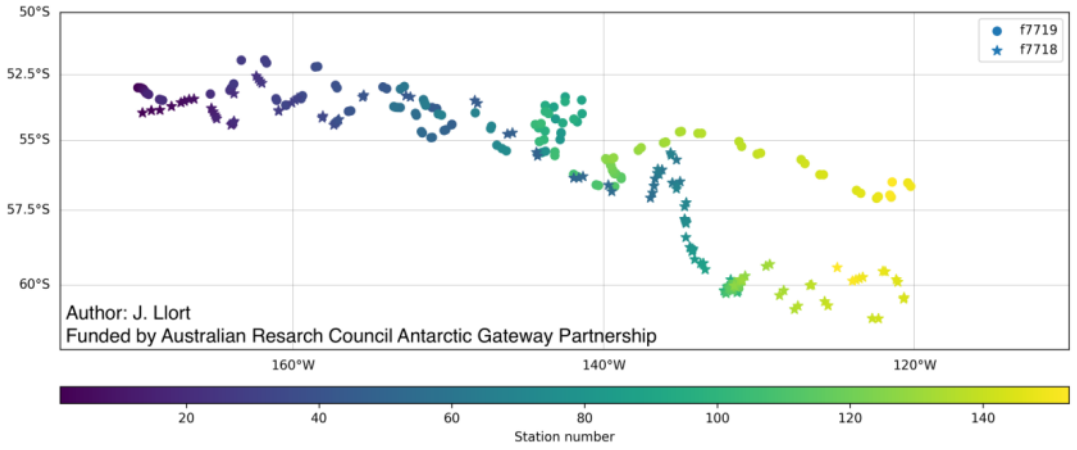
UTAS – Southern Ocean Spring Bloom

Pete Strutton
Joan Llort Jordi
Helen Philips

APEX AMS – 7718/9
- SBE 41CP
- AADI 4330
- WET Labs FLbbbb
- Satlantic OCR-504 ICSW
- Satlantic OCR-504 R10W
- WET Labs C-Rover

APEX EM -- 7789



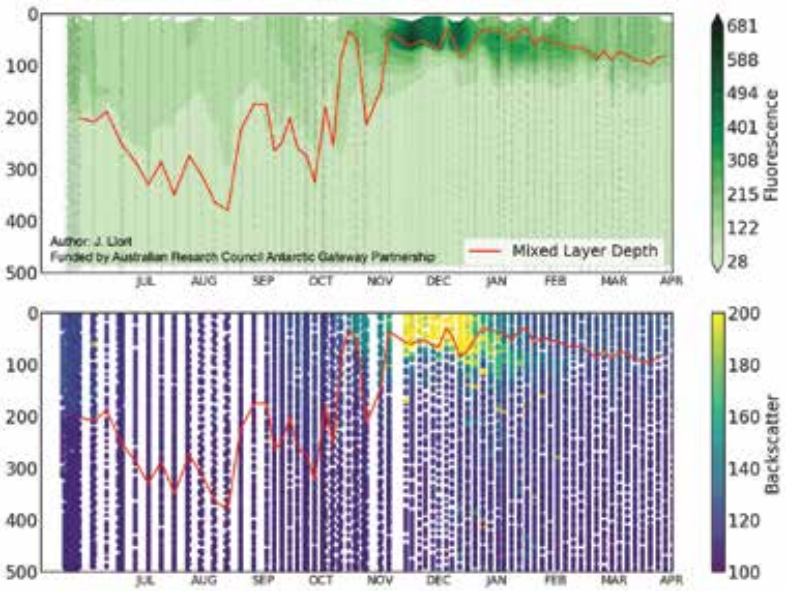


Images Courtesy of Joan Llort

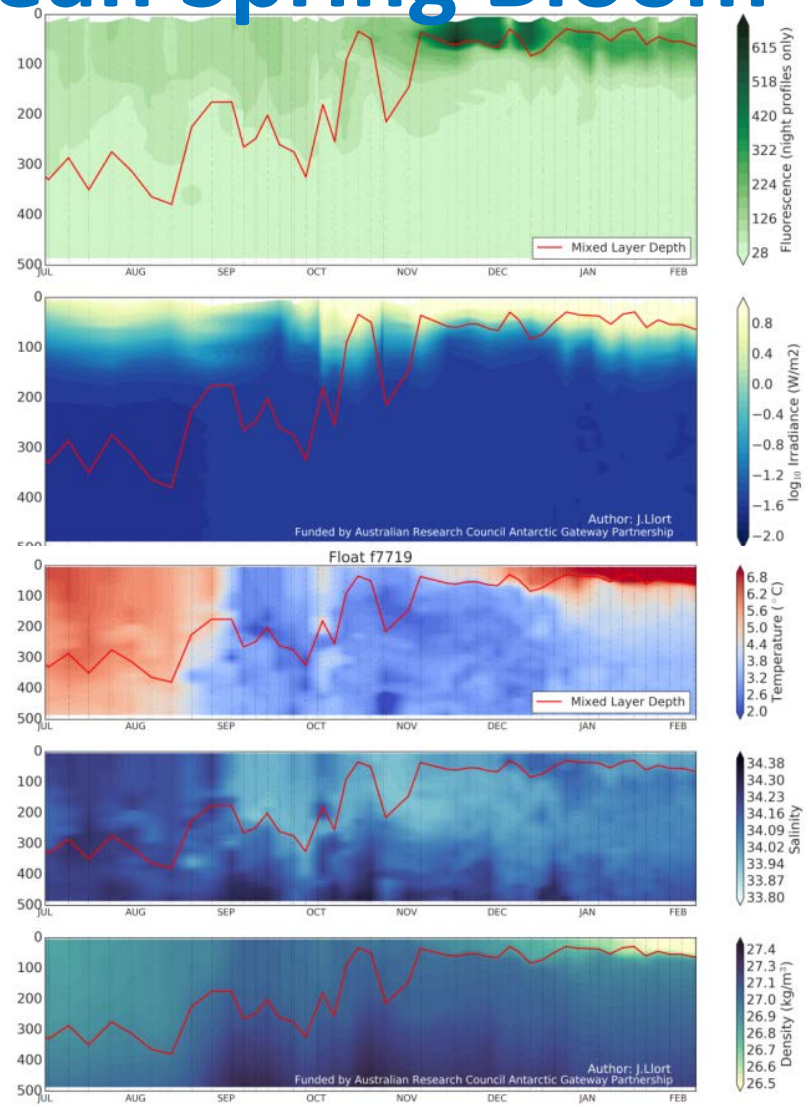
UTAS – Southern Ocean Spring Bloom

170 Profiles to 600 m Over 8 Months
Seasonal Ascent Intervals
50% of Battery Remaining

Bloom November – December
January -- FL increase below Mixed Layer



Images Courtesy of Joan Llort



APEX – EM
Current Profiler

Iridium CS/RUDICS and GPS

SBE 41CP

Electrode Ring

Absolute Current or
Current Shear

Rotary Vanes

Patented 2000 dbar Composite Hull
Lower Weight, Greater Endurance

Lithium Batteries

APF-9i
Optional AADI 4330 Optode
Optional FLbb or FLbbCD

APEX Deep

SBE 61

AADI 4330 or RINKO AROD-FT

Iridium CS/RUDICS and GPS

6000 dbar Glass Sphere Hull

Lithium Batteries

APEX Deep

Recent Developments

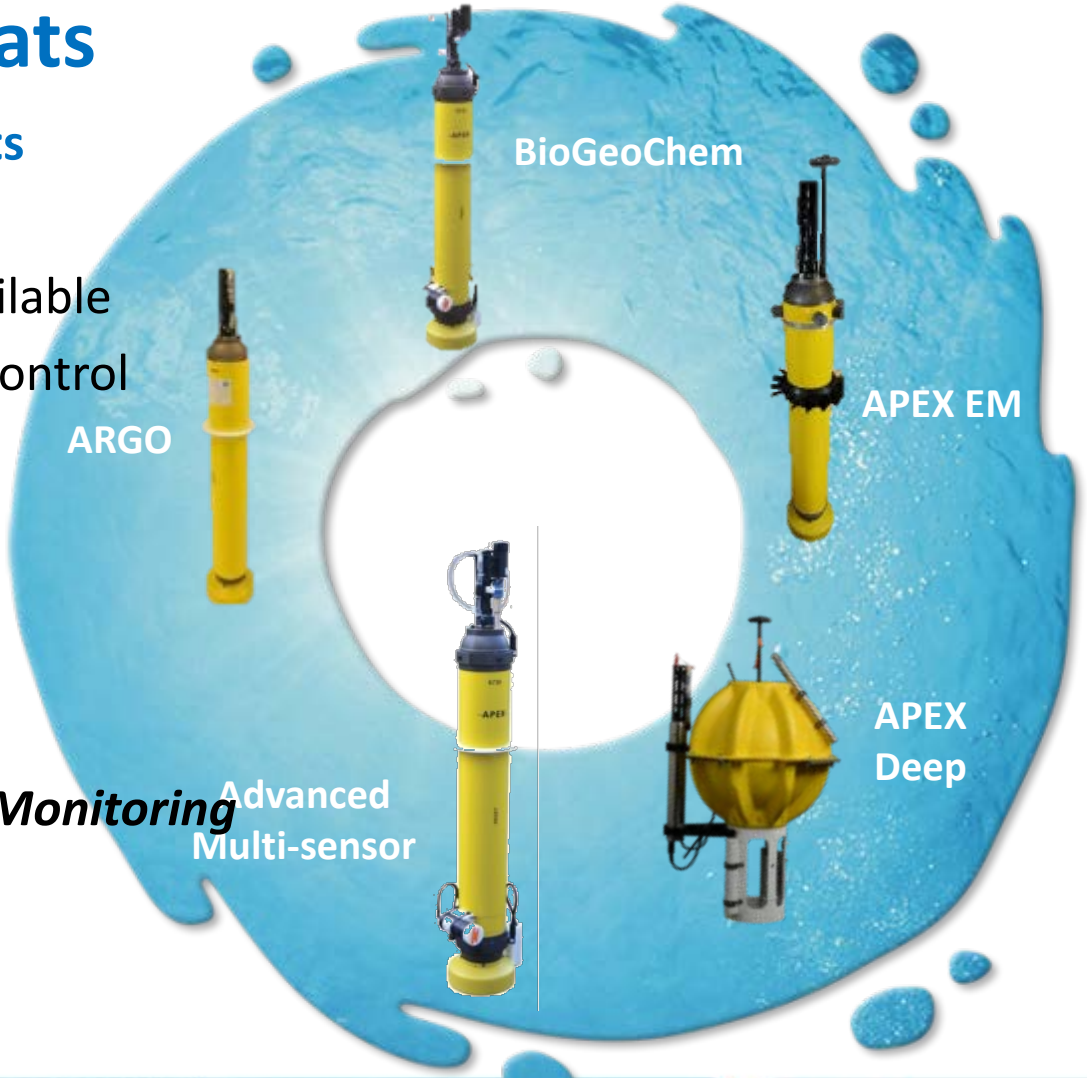
- APEX Deep 13, 15, 16 & 17
  - Developed Leaks During Early Profiles
  - Three Recovered and Returned to TWR
- Seawater Intrusion thru Connectors
  - Teledyne Scientific Analysis
    - X-Rays
    - Dye Penetrant Tests
  - Documented Leak Paths
  - Replaced Connectors with Penetrators
- Redundant Hydraulic Filter Cracked
  - Removed Filter from Design
- CTD Salinity Drift
  - Working with SBE
  - Updated TWR Procedures

Vehicles

APEX Profiling Floats

World Leader in Profiling Floats

- Over 8000 delivered
- Diverse configurations available
- Advanced command and control options
- World's first 6,000 m rated profiling float



Long Duration Water Column Monitoring

APEX