

Aerial drones for science, outreach, and operations

- **Grand Challenge:** Bridge the gap between in-water local measurements and low-res high-coverage satellite observations
- **Technology** – Autonomous Aerial Vehicle with Flexible Payload
- **Data** - Geolocated still multispectral images (project-specific video)
- **Impact** - Integrated ecosystems view at relevant scales
 - Management and contextual information matching oceanographic
 - Improved predictability

TEAM MEMBERS

- Principal Investigator – John Ryan
- Project Manager – Ben Erwin
- Lead Scientist – Steve Haddock
- Lead Engineer – Tom O'Reilly
- Science – Chavez, Benoit-Bird, Katija, Takeshita, Cullen
- Engineering/DMO – French, Cline, Rueda, Pargett, Kieft, Fitzgerald

Science Plans

- BioMapping (Haddock, Chavez, Benoit-Bird, Katija, Ryan, Takeshita, Save Our Shores)
- Foraging ecology (Ryan, Benoit-Bird)
- Predatory/protective interaction among whales (Ryan, Benoit-Bird)
- Generate compelling content for outreach (MBARI, MBA, MBNMS)

BioMapping: plankton, mammals, turtles, kelp, eelgrass, debris, ocean fronts...



Drone science use case: targeted visual & acoustic sensing

The Soundscape and Acoustical Ocean Ecology projects are collaborating with Jared Figurski to enable targeted passive acoustic sensing, supporting studies of marine mammal foragers / predators & forage species.

Integrating targeted drone-based imaging with passive acoustics would enable exploration and discovery of species behavior and interactions.

Example 1: Foraging ecology

Humpback whales sound during foraging near-surface
(K. Benoit-Bird, spring 2018)



Gray whales amid fish school,
southern Monterey Bay



Drone science use case: targeted visual & acoustic sensing

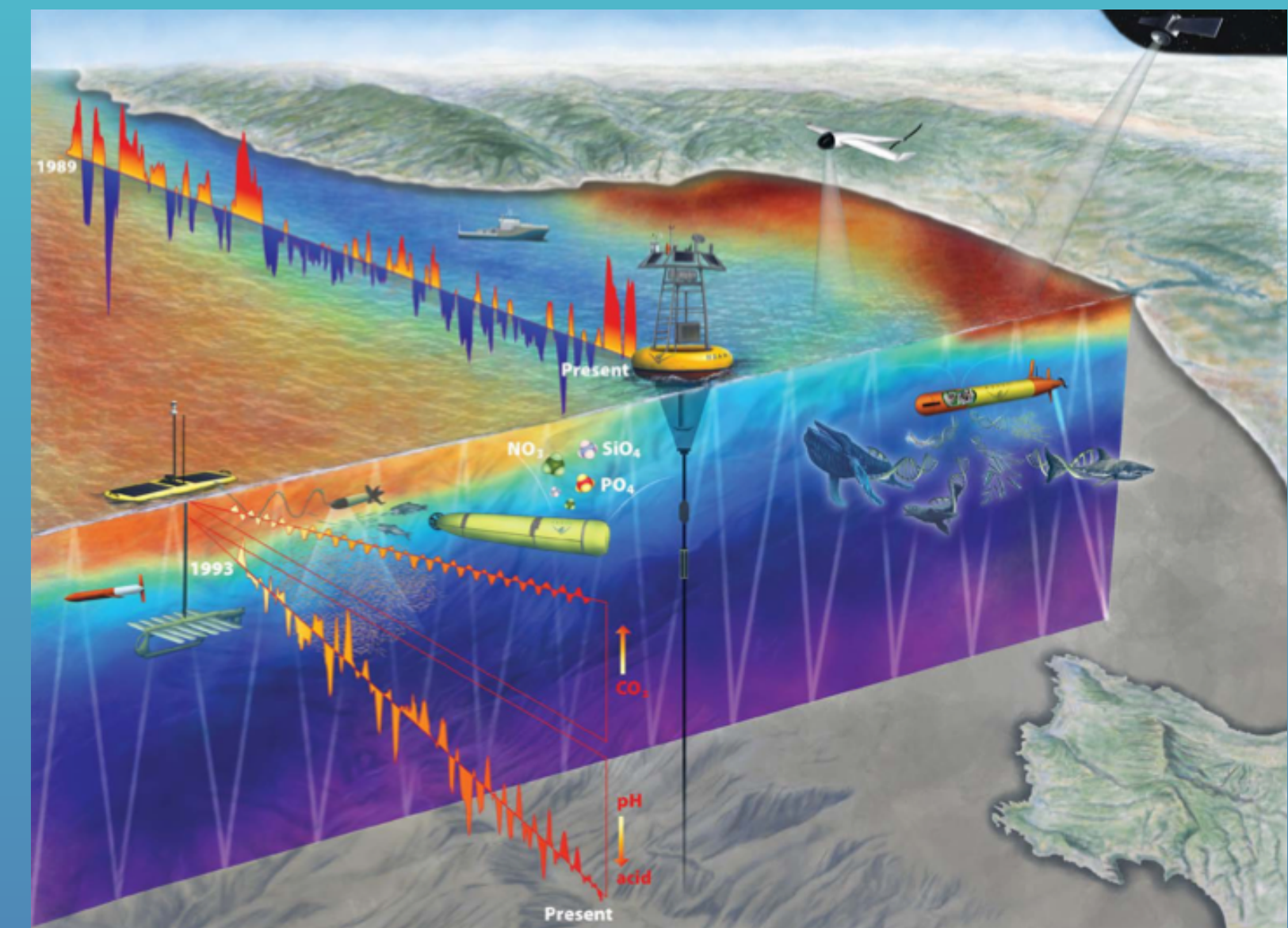
Orca predation on gray whale calves during spring / summer can elicit protective actions not only by the mother, but also across species as humpbacks bodily and vocally intervene.

Collaborations with MLML researchers and local whale watching captains would support event detection. Response with targeted visual and acoustic observations would reveal interactions between species.



Longer-Term Plans

- Thermal IR, Multi-spectral, mass spectrometer
- Augment/combine with acoustics, AUV, USV, ship, satellite data
- Aerosol measurements
- Water sampling



Marine Ops applications

- RF tag locator
 - Locate surfaced MBARI vehicles/assets
 - Tagged animals
- Data mule
- Out-of-sight operations (ship- or land-based)
- [Other potential applications](#)

Policy, regulations

- MBARI policies (DMO/Kelly document)
- Local and federal regulations – FAA, Sanctuary
- Additional considerations requiring permits
 - Beyond visual-line-of-sight piloting
 - Night flying

Relevance to MBARI

- Targeted/adaptive sampling
- Persistent ocean presence (rapid response)
- Increase public awareness of ocean environment and exploration
- Focus on processes at air-sea interface
- Conservation, habitat monitoring
- Collaborative platform

Collaborators

- Andrew DeVogelaere - **MB National Marine Sanctuary**
- K. O'Dea - Exec. Director - **Save Our Shores**
- Maura Orescanin - **Naval Postgraduate School**
- Raphe Kudela, **UCSC** – kelp surveys
- Kurt Kiesow, Jupiter Research Foundation – RF tag locator
- LSTS/Porto
- Jeremy Goldbogen - **Hopkins Marine Station**
- Ari Friedlander
- Monterey Bay Whale Watch
- Other potential collaborators
 - Barbara Block - Stanford
 - Kyle Van Houtan - **Monterey Bay Aquarium**



Eyes Over Puget Sound

Summary

Stories

Diving & critters

Climate & streams

Combined factors

Marine water

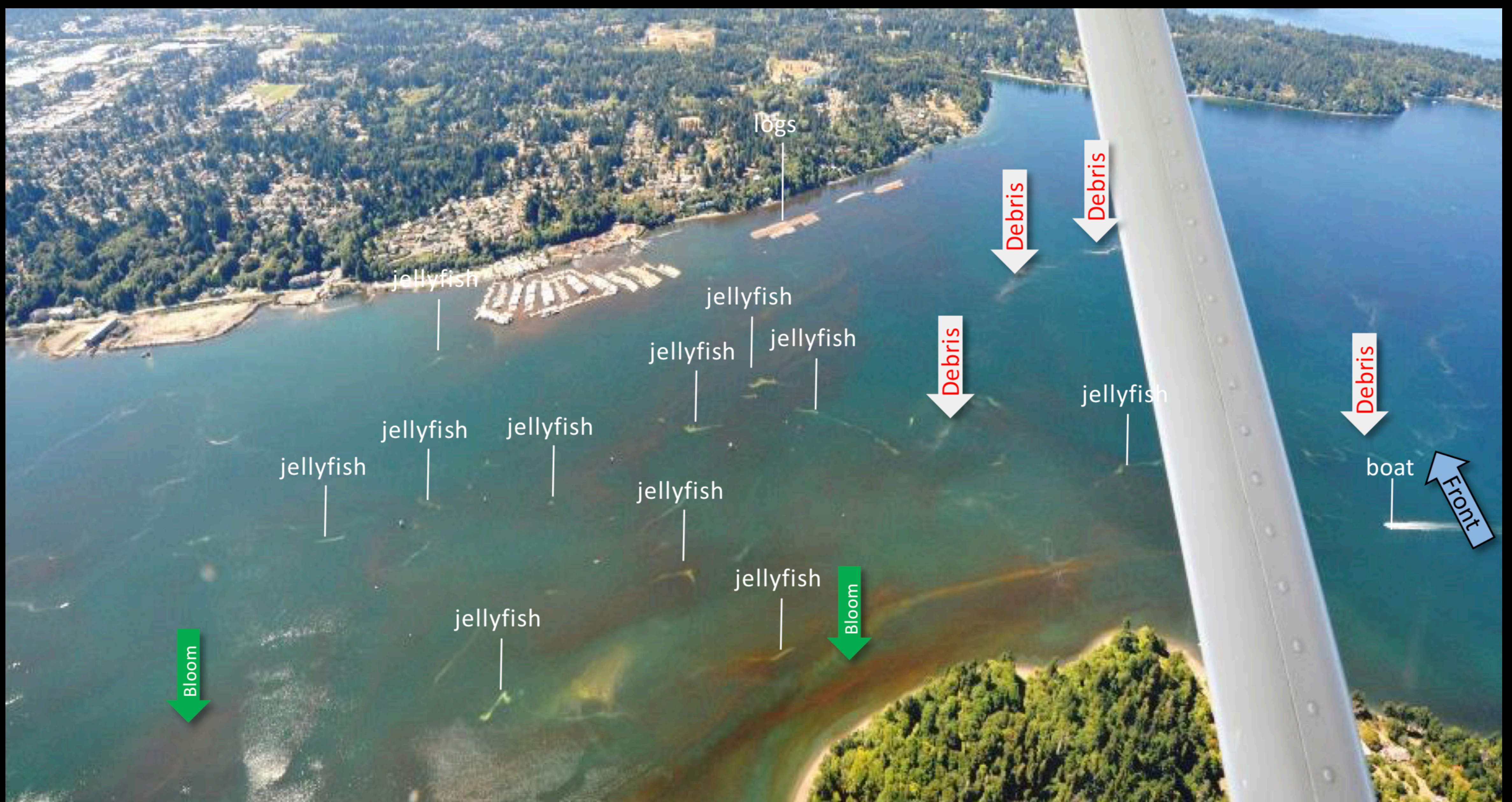
Aerial photos

Info

Surface Conditions Report, *April 19, 2018*



Airplane-based
Regularly Since 2011



Strong red-brown bloom and abundant jellyfish patches and organic debris at surface.
Location: Budd Inlet (South Sound), 2:25 PM.

Processing example



Processing example



255 - (Red-Green)

Platform considerations

Fixed Wing VTOL

QuadCopter

65 ha

700 ha

Potential Survey area: At 100m elevation • 2.5cm/pixel

Drone vehicle options

- Wide range of payload, duration, range, cost
- Long duration/range drone
- Up to Multi-kg payload
- Year 1:
 - Local surveys
 - Instrument and camera comparisons
 - Data and image processing
- Year 2-3: Longer range and routine operations

FlightWave VTOL 300g payload • 100km range



Tron VTOL

2kg payload • 90km range

