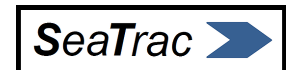


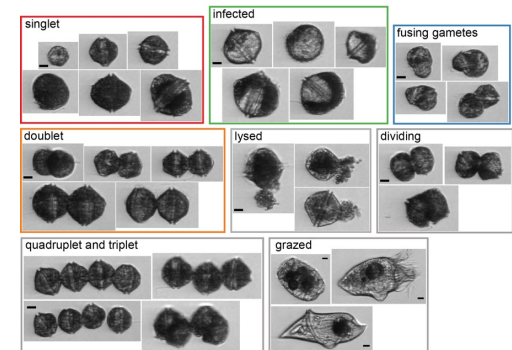
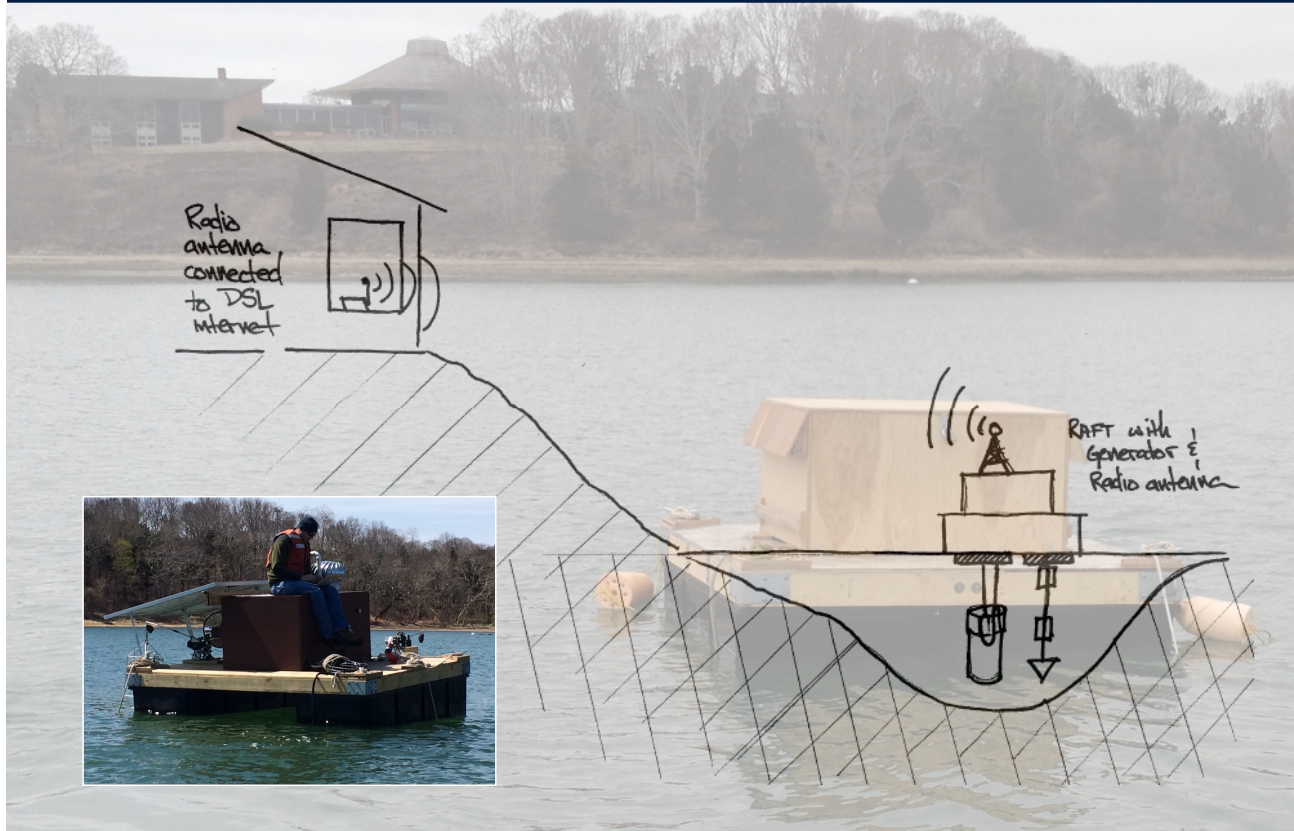
PhytO-ARM: Phytoplankton Observing- Automated Remote Management, a ROS-based sensor integration system and its applications in aquaculture

Michael Brosnahan, Ryan Govostes, Verena Lucke, Don
Anderson, Greg Doucette, Kate Hubbard, and Célia Villac

GlobalHAB Automated in situ sensor symposium
26 August 2022



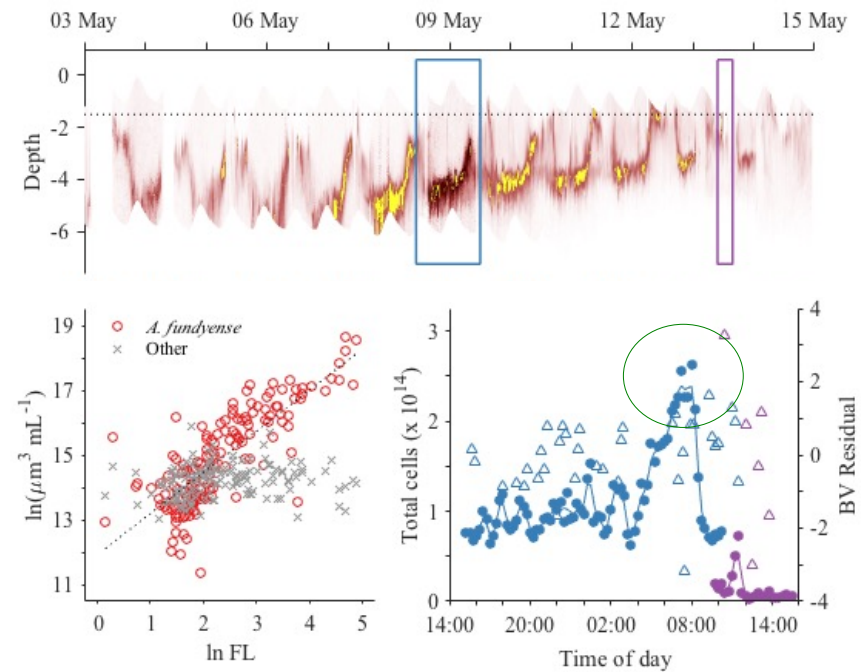
Putting IFCBs in interesting places...



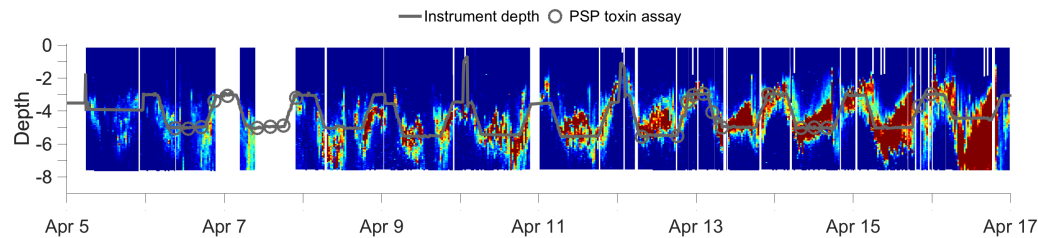
Many HABs migrate



Many HAB dinoflagellates migrate vertically through the water column!



How to more easily maintain and share?



IFCB and ESP thin layer tracking/sampling



Capability increased substantially over time but also complexity > challenging to maintain and share

Need for a more unified/standardized design for ease of maintenance



System replicated for a study at a Swedish mussel farm



WOODS HOLE OCEANOGRAPHIC INSTITUTION

| Sampling from fixed and mobile platforms

2020 Fixed-site IFCB and IFCB-ESP installations



Mobile platforms to be tested in 2021



New platforms tests – working toward capability to redistribute sensors across the region as needed

PhytO-ARM barge

Supports deployments of IFCB, ESP and profiling CTD



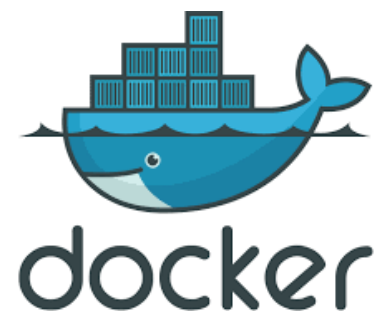
| PhytO-ARM goals

Create free, open-source software and hardware designs that can easily be adapted to meet the needs of small- to large-scale farms, monitoring agencies, and others

Software to be web-based and 'containerized' with operator and public facing dashboards for remote system management

Aim to adopt and implement emerging, open-source Internet-of-Things standards

Share data in ERDDAP formats to facilitate sharing



COTS/open design winch

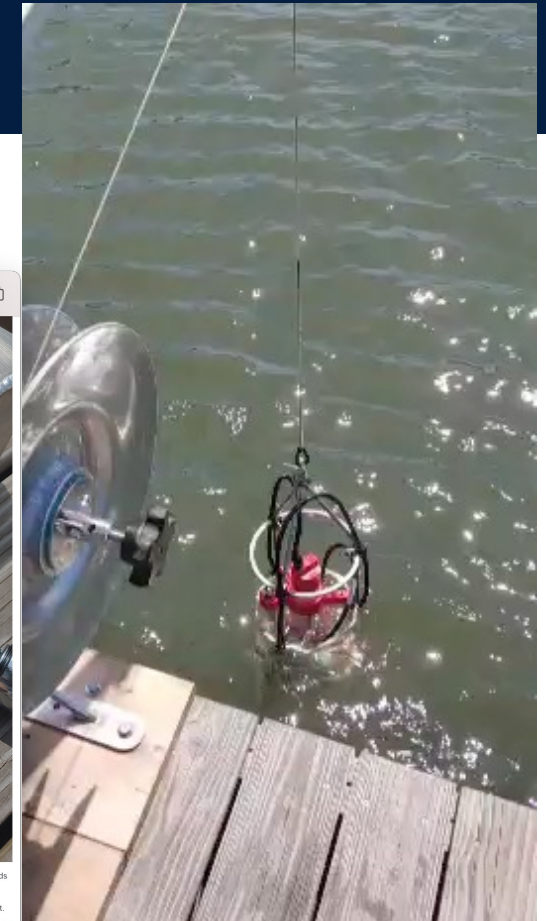
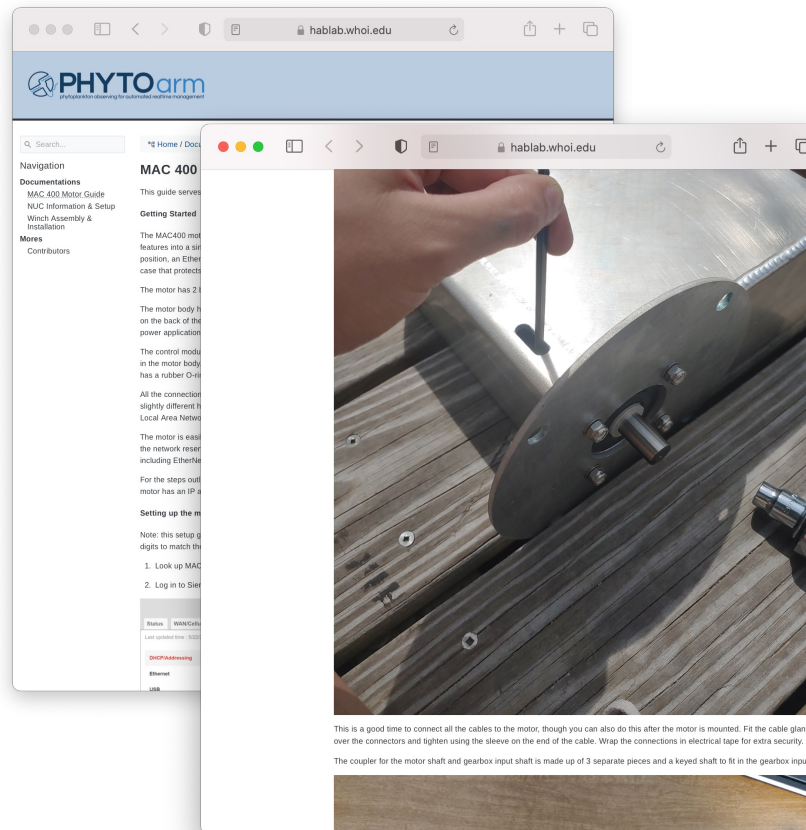
COTS = Commercial-off-the-shelf

Bill of materials ~5K
(without sensors)

Emphasis on documentation
(markdown web pages, git repos)



Verena Lucke



Adoption of ROS



One of several projects at WHOI adopting ROS



Ryan Govostes
WHOI IS App Dev



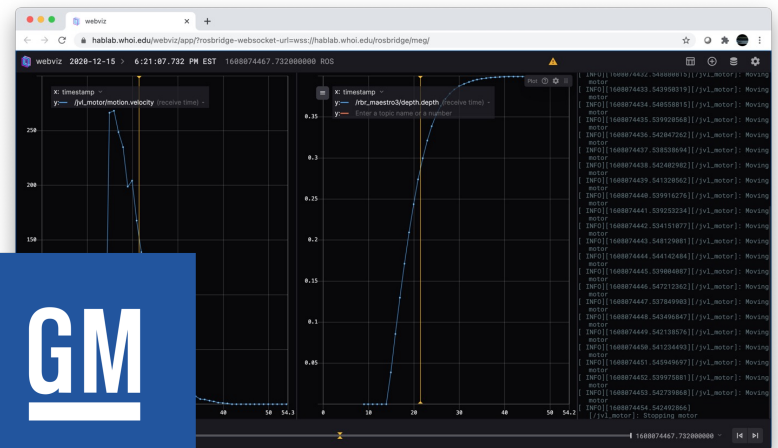
ROS is middleware....

Provides an anonymous publish/subscribe mechanism so different sensors, actuators, processes, etc. are aware of (and known to) other processes

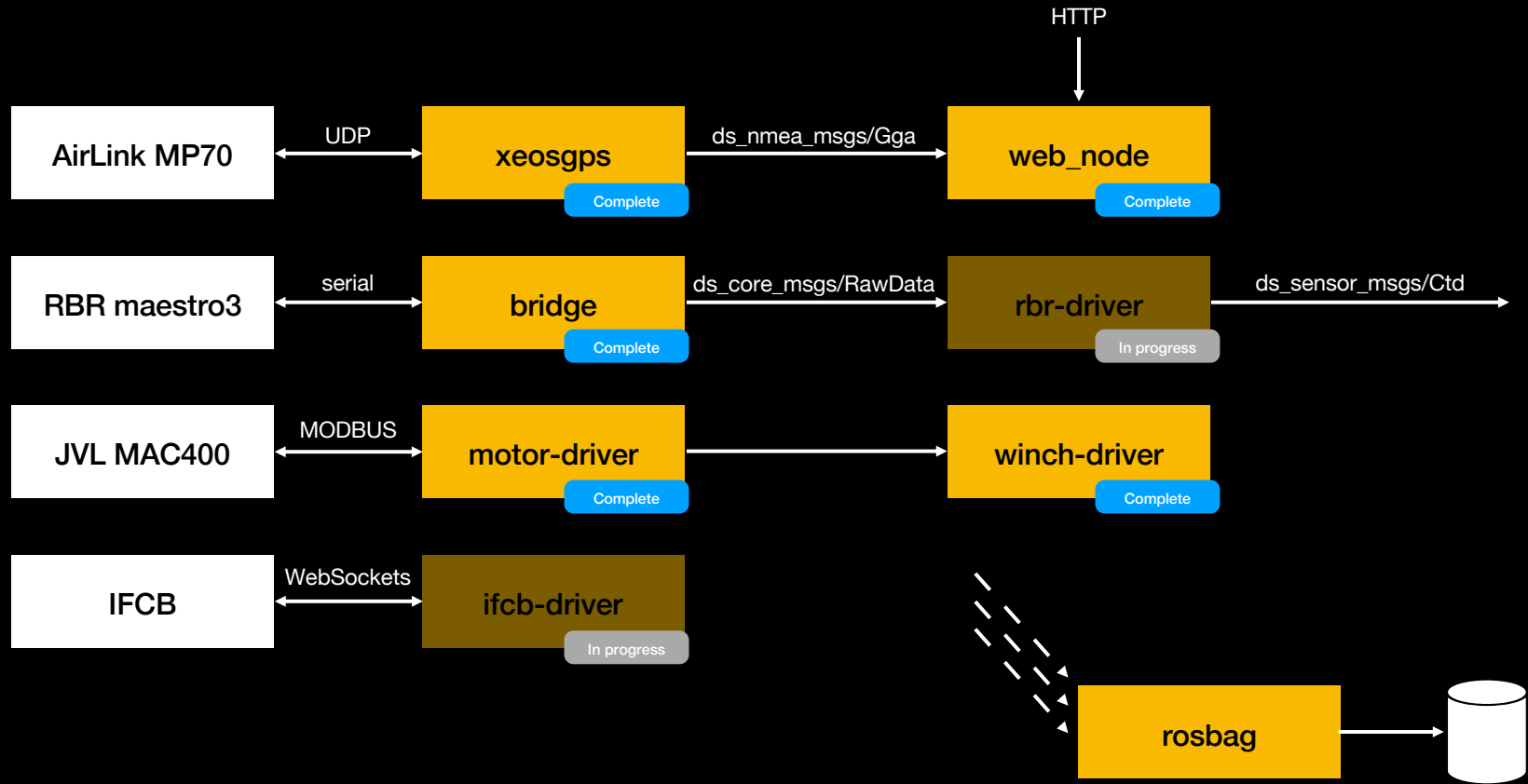
Makes projects more modular, easier to share code, sensors, and other systems!



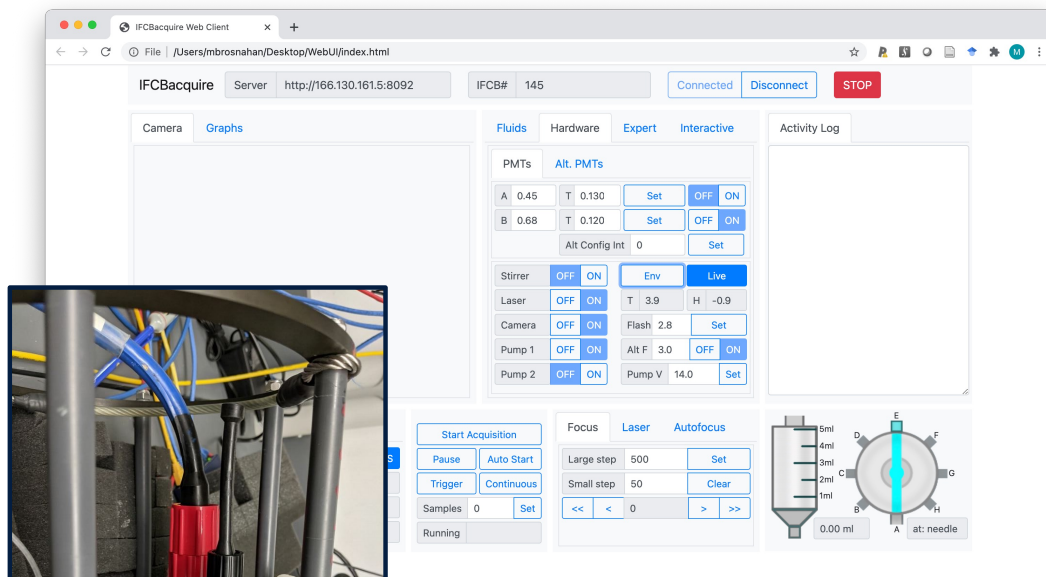
Webviz/Foxglove



March 2021



Collaboration with McLane



New bulkhead/vent cap for direct connection to CTD

Sample bin tagging through PhytO-ARM http queries

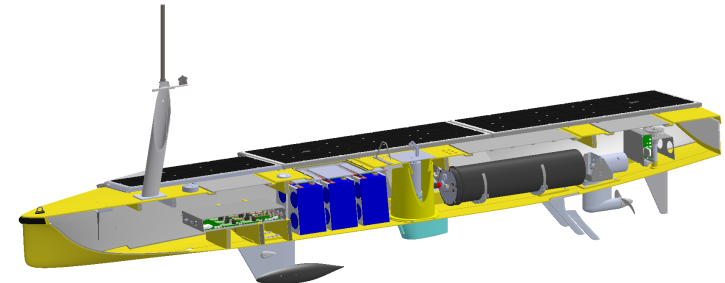
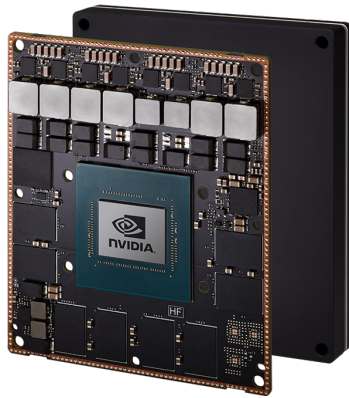


Vinnie Ferreira, Tom Fougere,
Ivory Engstrom

New Linux variant of IFCB software

Includes an API! Facilitates ROS integration and other development

| On platform image classification



All PhytO-ARM code has been developed on a Jetson board running ARM-based Ubuntu 20.04 OS

Ongoing work with McLane to replace stock IFCB CPU with the Jetson

Classification node uses ONNX and Triton to run same models as deploy on WHOI HPC system

| Demo



Automated nursery management through PhytO-ARM



Collaboration with Dan Ward, Ward Aquafarms LLC (N. Falmouth)

Commercial oyster, bay scallop and sugar kelp farm

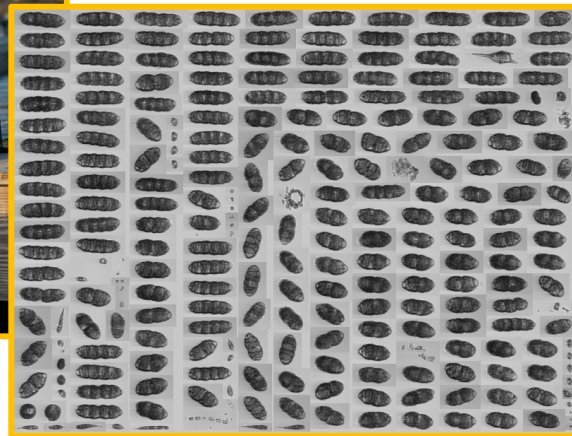
Aquaculture R&D – steelhead, tautog, and quahogs

Farm has suffered severe die-offs of shellfish nursery animals due to rust tides (*Margalefidinium polykrikoides*)

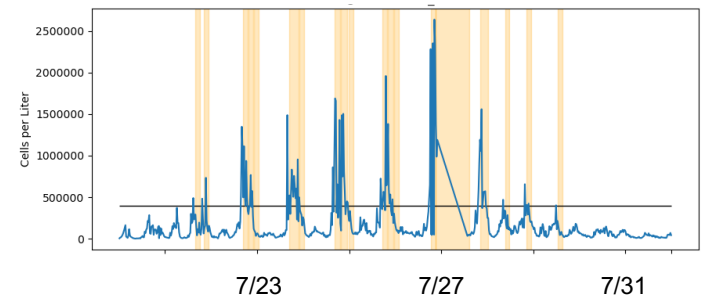
Automated nursery management through PhytO-ARM



Trigger aeration, turn off nursery pumps when *Margalefidinium* are present



Simulation from 2018 deployment



Response within 1 hour of exceedance

Faster responses require real-time, on-sensor image classification



Sydney Batchelder, Ryan Govostes, Mrun Pathare

| Summary

PhytO-ARM is a collection of tools for rapid integration of IFCB into networks of sensors and devices

Configurations are highly adaptable to a variety of platforms – from stationary barges to shipboard installations and mobile autonomous vehicles

Data produced by PhytO-ARM are associated with IFCB bins at time of collection and distributed through existing IFCB data systems (the IFCB dashboard)

We aim to make code and hardware designs for several elements available by the end of 2022

Acknowledgements



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Tom Fougere

Don Anderson
Greg Doucette
Kate Hubbard
Célia Villac

Robert Moorhead
Bengt Karlson



Dan Ward
Jane Disney
Mark Hanscome

