Project Number: 901206

Project Start: Jan. 1, **2012** **Project Duration (in years):** **3**

Please indicate what type of project is being proposed (mark only one).

[ ]	[X]	[ ]	[ ]	[ ]
Feasibility/Scoping [Less than 100 days effort]	**Development**[1]	**Research**	**Infrastructure**[1]	**Education**
	[ ]	[ ]		
	Time Series	**Institute Initiative**		

Project Manager[2]: Gene Massion
Principal Investigator: Ken Johnson
Lead Scientist: Ken Johnson
Lead Engineer: Gene Massion

Project Title:
Development of a Coastal Profiling Float

[1] Development and infrastructure projects must complete the risk matrix (see item #5 at the end of the proposal form).
[2] Not all projects will require all four titles to be filled in. Please indicate individuals only for those titles that are appropriate for your project.

1) ABSTRACT

A warming climate, increased use of nitrogen fertilizers, acidification, loss of sea ice, decreasing oxygen concentrations and a variety of other processes are expected to impact coastal waters. Since much of the global ocean carbon cycling occurs in relatively shallow coastal waters where nutrients are upwelled to the surface, an observing system that can be distributed on a global scale is needed to provide assessments of the effects of these processes on fundamental biogeochemical processes such as net community production and carbon export. We propose an effort to develop a profiling float optimized for use in coastal waters that can serve as the basis of an economically sustainable coastal observing system. The goal is to provide the kind of "salient, credible and legitimate"[1] knowledge that can strengthen the role of science in public policy and decision making. Our approach is to extend the reach of the existing, successful global Argo array into the coastal zone by modifying existing Argo profiling float technology for operation in coastal waters. Our unique contribution would be twofold. First, development of a platform with a bottom "parking" mode optimized to increase the float residence times in the coastal zone. Second, this platform will be optimized to ease integration of sensor suites specifically targeting coastal issues e.g., pH, nitrate, oxygen and bio-optical sensors.

[1] David & Lucille Packard Foundation Science Strategy: Linking Knowledge with Action

2) PROPOSAL

a) New Projects

Statement of the problem, why it is important

A warming climate, increased use of nitrogen fertilizers, acidification, loss of sea ice, decreasing oxygen concentrations and a variety of other processes are expected to impact coastal waters. An observing system that can be distributed on a global scale is needed to provide assessments of the effects of these processes on fundamental biogeochemical processes, such as net community production and carbon export. There are no such coastal observing systems that are now available. Coastal moorings are typically expensive, require a skilled labor force for continual maintenance, and are quite susceptible to damage from vessel traffic and fishing. Gliders are also expensive, require a highly trained group to service them between missions, and they carry few sensors.

The Argo array, based on a network of 3000+ profiling floats distributed throughout the open ocean, has been, arguably, the only successful model for global scale sensor arrays in the ocean. The main focus of Argo is to provide a measurement of the changing heat content of the global ocean. The profiling floats used by Argo are optimized for deployment in waters deeper than their 2000 meter maximum profiling depth. Argo has not focused on the coastal zone simply because shallow coastal waters hold little heat. We are now successfully equipping profiling floats with biogeochemical sensors with a goal to provide similar assessments of the time variations in open ocean cycles of carbon, nitrogen and oxygen. However, in contrast to heat, much of the global ocean carbon cycling occurs in shallow coastal waters where nutrients are upwelled to the surface. Thus assessments of the changing elemental cycles in the open ocean will require sensor arrays that can be economically deployed in large numbers for decades throughout the coastal regions of the world. We believe that profiling floats are best suited for this type of global observing system for several reasons. They are relatively low cost and do not require continual service, as do gliders and moorings. For example one glider costs roughly $150K and it typically requires approximately $60K per year to operate a glider (based on conversations with O. Schofield, C. Lee and D. Rudnick). Over 5 years, this represents a cost of $450k. A profiling float costs approximately $50K and, based on current Argo statistics, is essentially maintenance free for at least 3-5 years. Nine profiling floats can be deployed for every glider over a 5 year period. At a 9 to 1 ratio, the economic advantage of a profiling float array is clear.

We propose an effort to begin development of a profiling float optimized for operation in coastal waters. Our unique contribution would be twofold. First, development of a platform optimized for coastal operation (water depths less than about 500 meters). Second, it will be optimized to ease sensor integration e.g., pH, nitrate, oxygen and bio-optical sensors. Specifically we propose to add a bottom parking mode that will substantially increase the float residence time inside the coastal region. Current Argo floats have a buoyancy engine that provides a relatively small buoyancy change, not nearly enough to provide even a moderate ability to “park” on the bottom (we do not use the term anchor since it implies a more permanent state than we are envisioning). In addition, this small buoyancy change requires a very precise pre-deployment ballasting process that currently must be run on each and every float. Because we will be working at shallower depths, we won’t need to overcome the same pressure difference and can use this saved energy to build in more buoyancy change. The Chemical Sensor lab has an ongoing relationship with Steve Riser’s Lab at UW, the leading developer of new enhancements for the standard APEX Argo float. We have discussed the project with Steve and we are pleased he has agreed to collaborate with us on this development and will be using APEX float as the starting point for our design.

Figure 1 is an example of the kind of data product currently possible from the global Argo array and provides approximately 9 years of O_2 and temperature data for an area near Hawaii. We believe the proposed project could generate similar plots in 4 dimensions economically sustainable over decades for not only O_2 and temperature but also a range of other parameters like pH and nitrate that are critical to understanding and managing coastal zones.

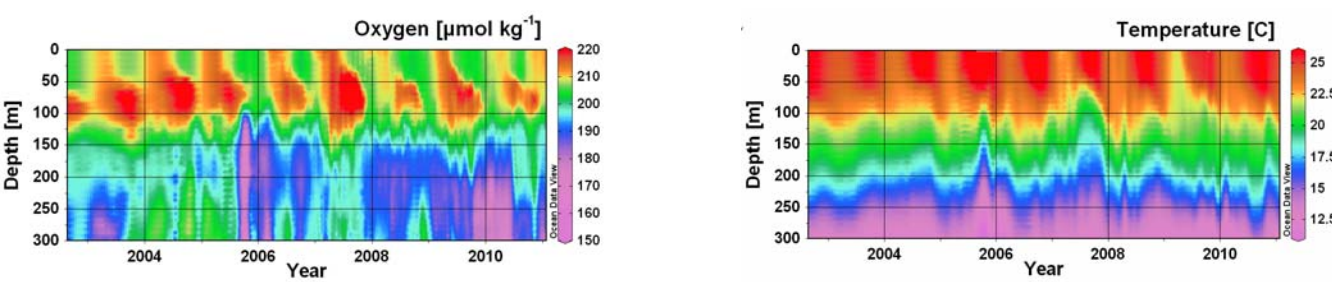

Figure 1. Nine years of O2 and temperature data collected near Hawaii by profiling floats deployed by the University of Washington

How does it relate/contribute to MBARI’s mission and strategic plan?

This proposed project relates and contributes to MBARI's mission and strategic plan at several levels. At the highest level relative to MBARI's mission statement, this project is a symbiotic collaboration between MBARI Engineering and MBARI's Chemical Sensor lab to develop a unique instrumentation system capable of providing economical measurements of fundamental properties required to understand natural phenomena in the critical coastal zone and how human activities are affecting these phenomena. More specifically, the proposed project directly addresses all 3 of the overarching goals in the 2011 strategic plan:

1. Develop or adapt innovative technologies that allow researchers to identify and resolve important questions and advance our understanding of the ocean.

2. Utilize those developments to explore and understand how natural ocean systems operate and how they respond to natural and anthropogenic change.

3. Transfer the knowledge gained, solutions devised, and the technology developed to communities outside of MBARI researchers, educators, policy makers, resource managers, industry, and the general public.

1) We are adapting innovative Argo technology to better understand important coastal processes. 2) We will utilize this technology with a targeted science field program throughout the project to validate the operation of the system, although the real benefit will be long term when large arrays of coastal profiling floats can be deployed. 3) Because the technology is an extension of the existing Argo technology, we have an existing community of users and commercial vendors to transfer the technology to.

In addition, the proposed project directly addresses the Ocean biogeochemistry 2011-2020 research theme identified in the Strategic Plan. In this section of the strategic plan measurements of ocean acidity, oxygen, temperature, density, nutrient density and trace metals are identified as major influences on ecosystem structure and function. The Chemical Sensor Lab had demonstrated the ability to measure all of these parameters on other platforms. This effort will move at least the first 5 of these measurements onto a platform that can be deployed in arrays across the coastal regions of the world. These measurements will also be of fundamental usefulness in project addressing the Ecosystem Dynamics 2011-2020 Research theme.

How does it relate/contribute to the Packard Foundation's Ocean Visions Grantmaking policies?

The Packard Foundation Strategic Framework for Oceans Grantmaking "concentrates on three interlinked objectives … Restoration of ecologically important fisheries, Improved coastal management; and, Enhanced scientific understanding of the functioning of marine ecosystems". The long term products of this project; economically sustainable 4D records of important coastal ocean parameters are critical input to the kind of policy making the Packard Foundation is explicitly supporting. More specifically, the Packard Foundation Science subprogram describes a "growing body of knowledge that can help determine the most effective strategies to strengthen the role of science in decision making". Their document *Science Strategy: Linking Knowledge with Action* describes the kind of knowledge required by policy and decision makers as 1) Legitimate 2) Salient and 3) Credible. We believe the global data currently generated by the Argo program meets all 3 criteria for several reasons. More than

3000 floats have been deployed since 2000. Two global data centers provide quality controlled data within 24 hours of reception. There is a large, global community of researchers using Argo data publishing over 100 papers per year. In addition, at least 16 operational centers around the world currently produce regional and global products based on Argo data. We expect the data generated by the proposed coastal profiling floats can be integrated into the proven Argo data system with all the advantages described above.

Approach to the problem

The Management Team has identified several issues including permitting and impact on Marine Protected Areas that must be addressed for this project to be successful and we have re-scoped our project to address these issues immediately (to simplify discussion, we'll refer to all these non-technical issues as permitting). We have already begun discussions with the Sanctuary and their responses suggest that this project can be included in the MBARI research permit with no substantive changes. Following is a comment from Andrew DeVogelaere regarding the issues with deploying several floats in the MBNS eventually leading to large arrays of floats in a coastal region, not necessarily Monterey Bay.

"Erica does not think your project would be a problem but it would need a permit. She suggests that you contact Mandy Allen at MBARI, and work through the MBARI institutional permit. You may already be covered, or Mandy could request a permit modification. Relative to permits, this kind of project is much less problematic than a cable like MARS."

Finally, we note that the industrial and ocean communities are moving towards greater acceptance of Li batteries. For example, Teledyne/Webb originally supported only alkaline battery deployments in floats, but now routinely includes Li batteries as an option. It is likely that future ocean observing will be based on systems using batteries with higher energy density, not lower and we will use this opportunity to better understand the permitting issues. As a risk mitigation measure, we have the option of using Li-ion secondary batteries which present a significantly lower risk than Li metal primary batteries and standard alkaline batteries are also a very reasonable alternative for all MBNS deployments. While all of the above leads to some confidence with respect to the MBNS permits, it does not resolve the greater question of permitting for large scale coastal arrays of profiling floats. We will also be pursuing this question as part of our planned permitting efforts.

Happily, the development part of this project is somewhat more straightforward than permitting. We aren't starting from scratch on this design. We start with the existing Argo APEX float design which allows us to leverage the existing relationship with Steve Riser's Lab at UW, the developers of this float. We expect to follow the usual process of defining science and design requirements, developing a preliminary design with prototyping as necessary to mitigate risk, hold a design review, finalize the design and review, build, test and deploy. As mentioned above, the permitting process is a significant predecessor to any substantial engineering effort. We suggest that a reasonable balance between a) optimism that we can successfully negotiate the permitting process and b) prudent expenditure of resources; is to make completion of the permitting process (or at least a reasonably high probability we can acquire the required permits in a timely fashion) the predecessor to the PDR on the project GANTT chart/schedule with a small amount of system engineering going on in parallel with the permitting process.

We are planning for a 3 year project. As mentioned, we've already started the process of understanding the permitting environment and we are making the assumption that we can successfully negotiate this process by the end of the second quarter of the first year. The majority of the engineering development will start Q3 year 1 through Q4 year 2. The third year will be science driven deployments, data analysis and publication(s). Transferring this technology to the larger ocean observing community will start in year 3.

Publications (from other projects over the last 5 years)

Paerl, R. W., K. S. Johnson, R. M. Welsh, A. Z. Worden, F. P. Chavez and J. P. Zehr. 2011. Differential distributions of *Synechococcus* subgroups across the California current system. Frontiers in Microbiology, 2, 59, doi: 10.3389/fmicb.2011.00059.

Cullison Gray, S. E., M. D. DeGrandpre, T. S. Moore, T. R. Martz, G. E. Friederich and K. S. Johnson. 2011. Applications of in situ pH measurements for inorganic carbon calculations. Marine Chemistry, 125, 82-90.

Plant, J. N., K. S. Johnson, S. E. Fitzwater, C. M. Sakamoto, L. J. Coletti, and H. W. Jannasch. 2010. Tidally oscillating bisulfide fluxes and fluid flow rates observed with in situ chemical sensors at a warm spring in Monterey Bay, California. Deep-Sea Research, I, 57, 1585-1595.

Johnson, K. S., S. C. Riser and D. M. Karl. 2010. Nitrate supply from deep to near-surface waters of the North Pacific subtropical gyre. Nature. 465, 1062-1065.

Martz, T. R., J. G. Connery and K. S. Johnson. 2010. Testing the Honeywell Durafet® for seawater pH applications. Limnology and Oceanography: Methods, 8, 172-184.

Moisander, P. H., R. A. Beinart, I. Hewson, A. E. White, K. S. Johnson, C. A. Carlson, J. P. Montoya and J. P. Zehr. 2010. Unicellular cyanobacterial distributions broaden the oceanic N_2 fixation domain. Science, 327, 1509-1511.

Johnson, K. S. 2010. Simultaneous measurements of nitrate, oxygen and carbon dioxide on oceanographic moorings: Observing the Redfield ratio in real-time. Limnology and Oceanography, 55, 615-627.

Johnson, K. S., W. M. Berelson, E. S. Boss, Z. Chase, H. Claustre, S. R. Emerson, N. Gruber, A. Körtzinger, M. J. Perry, S. C. Riser. 2009. Observing biogeochemical cycles at global scales with profiling floats and gliders: prospects for a global array. Oceanography, 22(3), 216-225.

Martz, T. R., H. W. Jannasch and K. S. Johnson. 2009. Determination of carbonate ion concentration and inner sphere carbonate ion pairs in seawater by ultraviolet spectrophotometric titration. Marine Chemistry, doi:10.1016/j.marchem.2009.07.002.

Plant, J. N., K. S. Johnson, J. A. Needoba and L. J. Coletti. 2009. NH4-Digiscan: an in situ and laboratory ammonium analyzer for estuarine, coastal and shelf waters. Limnology and Oceanography: Methods, 7, 144-156.

Sakamoto, C. M., K. S. Johnson and L. J. Coletti. 2009. An improved algorithm for the computation of nitrate concentrations in seawater using an in situ ultraviolet spectrophotometer. Limnology and Oceanography: Methods, 7, 132-143.

Elrod, V. A., K. S. Johnson, S. E. Fitzwater, and J. N. Plant. 2008. A long-term, high-resolution record of surface water iron concentrations in the upwelling-driven central California region, Journal of Geophysical Research, 113, C11021, doi:10.1029/2007JC004610.

Martz, T. R, K. S. Johnson and S. C. Riser. 2008. Ocean metabolism observed with oxygen sensors on profiling floats in the Pacific. Limnology and Oceanography, 53, 2094-2111.

Johnson, K. S. and J. A. Needoba. 2008. Mapping the spatial variability of plankton metabolism using nitrate and oxygen sensors on an autonomous underwater vehicle. Limnology and Oceanography, 53, 2237-2250.

Jannasch, H.W, L. J. Coletti, K. S. Johnson, S. E. Fitzwater, J. A. Needoba and J. N. Plant. 2008. The Land/Ocean Biogeochemical Observatory: A robust networked mooring systems for continuously monitoring complex biogeochemical cycles in estuaries. Limnology and Oceanography: Methods, 6, 263-276.

Holm, C. S., Z. Chase, H. W. Jannasch and K. S. Johnson. 2008. Development and initial deployments of an autonomous in-situ instrument for long-term monitoring of copper (II) in the marine environment. Limnology and Oceanography: Methods, 6, 336-346.

Buesseler, K. O., S. Doney, D. M. Karl, P. W. Boyd, K. Caldeira, F. Chai, K. H. Coale, H. J. W. de Baar, P. Falkowski, K. S. Johnson, R. Lampitt, A. Michaels, W. Naqvi, V. Smetacek, S. Takeda and A. Watson. 2008. Ocean iron fertilization—moving forward in a sea of uncertainty. Science, 319, 162.

Riser, S. C. and K. S. Johnson. 2008. Net production of oxygen in the subtropical ocean. Nature, 451, 323-325.

Comeau, A. J., M.R. Lewis, J.J. Cullen, R.S. Adams, J. Andrea, S. Feener, S.D. McLean, K.S. Johnson, L.J. Coletti, H.W. Jannasch, S.E. Fitzwater, C. Moore and A.H. Barnard. 2007. Monitoring the Spring Bloom in an Ice Covered Fjord with the Land/Ocean Biogeochemical Observatory (LOBO). MTS/IEEE Oceans 2007, 1-7, doi: 10.1109/OCEANS.2007.4449185.

Johnson, K. S., Boyle, E., Bruland, K., Coale, K., Measures, C., Moffett, J., Aguilar-Islas, A., Barbeau, K., Bergquist, B., Bowie, A., Buck, K., Cai, Y., Chase, Z., Cullen, J., Doi, T., Elrod, V., Fitzwater, S., Gordon, M., King, A., Laan, P., Laglera-Baquer, L., Landing, W., Lohan, M., Mendez, J., Milne, A., Obata, H., Ossiander, L., Plant, J., Sarthou, G., Sedwick, P., Smith, G. J., Sohst, B., Tanner, S., Van den Berg, S., Wu, J. 2007. The SAFe Iron Intercomparison Cruise: An International Collaboration to Develop Dissolved Iron in Seawater Standards. Eos, Transactions of the American Geophysical Union, 88, no. 11, 131-132.

Needoba, J. A., R. A. Foster, C. Sakamoto, J. P. Zehr, and K. S. Johnson. 2007. N_2-fixation by unicellular cyanobacterial diazotrophs in the temperate, oligotrophic North Pacific. Limnology and Oceanography, 52, 1317-1327.

Johnson, K. S., J. A. Needoba, S. C. Riser, and W. J. Showers. 2007. Chemical sensor networks for the aquatic environment. Chemical Reviews, 107, 623-640, doi 10.1021/cr050354e.

Massion publications (last 5 years)

Preston, C., R. Marin III, S. Jenson, J. Feldman, E. Massion, E. DeLong, M. Suzuki, K. Wheeler, D. Cline, N. Alvarado, and C. Scholin. 2009. Near real-time, autonomous detection of marine bacterioplankton on a coastal mooring in Monterey Bay, California, using rRNA-targeted DNA probes. *Environmental Microbiology* 11:1168-1180. doi:10.1111/j.1462-2920.2009.01848.x

Roman, B., C. Scholin, S. Jensen, E. Massion, R, Marin III, C. Preston, D. Greenfield, W. Jones, and K. Wheeler. 2007. Controlling a Robotic Marine Water Sampler with the Ruby Scripting Language. *Journal of American Laboratory Automation* 12: 56-61.

Greenfield, D.I., R. Marin III, S. Jensen, E. Massion, B. Roman, J. Feldman, C. Scholin. 2006 Application of the Environmental Sample Processor (ESP) methodology for quantifying *Pseudo-nitzschia australis* using ribosomal RNA-targeted probes in sandwich and fluorescent *in situ* hybridization. *Limnology and Oceanography: Methods* 4: 426-435.

Scholin, C, G. Doucette, S. Jensen, B. Roman, D. Pargett, R. Marin III, C. Preston, W. Jones, J. Feldman, C. Everlove, A. Harris, N. Alvarado, E. Massion, J. Birch, D. Greenfield, R. Vrijenhoek, C. Mikulski, K. Jones. Remote detection of marine microbes, small invertebrates, harmful algae and biotoxins using the Environmental Sample Processor (ESP). *Oceanography 22:158-167*

c) New and Continuing Projects: Plans for 2012

The plan for this effort can be divided into 2 parts, research activities (primarily science staff) and engineering/technology activities (primarily engineering staff). The research activity primarily consists of a modeling effort by Sergey Frolov and is described in more detail below. There will also be a low level task by the Chemical Sensor lab to ensure the data acquired by the floats meets reasonable quality control standards. The primary detailed engineering activity is evaluating current profiler buoyancy engine technologies, developing an approach that will increase the buoyancy change capability to the required level and implementing this approach on a modified Argo Apex float. More detail on the engineering activities is also provided below.

Research Activities

Sergey Frolov has expressed an interest in expanding his current work to include 2 tasks for this project.

1) To develop a float trajectory prediction system using existing operational forecast [http://ourocean.jpl.nasa.gov/MB/] for the Monterey Bay area. We plan to use this prediction system for adaptive mission planning where a float heading in the "wrong" direction could be re-missioned to take advantage of potentially more advantageous currents in order to increase the residence time in the desired measurement volume.

2) To describe statistics of the float residence times along the U.S. West Coast. This task will utilize the coast-wide NCOM model available to us through collaboration with the Navy. We plan to use the residence-time statistics to determine usage scenarios and design criteria for the float. No MBARI support is requested for Sergey Frolov

Engineering/technology development

A top level Gantt chart of the engineering tasks is shown in Figure 2. Please note the majority of the effort is dependent on successful navigation of the permitting process. As we all know, permitting is a bit of a black hole so, as a starting point, we have included 15 days of Gene's time to work with Mandy, Linda and anyone else who can help negotiate this process. We have adopted a mildly optimistic approach that has a small amount of system engineering going on in parallel with the permitting process in order to make sure we are ready to start the engineering immediately after we have a reasonable belief the permits can be acquired. The mechanical engineering effort is primarily the design of a more capable buoyancy engine and redesign of the existing float frame and hull to better accommodate coastal instrumentation. Both gear and piston pumps are currently in use by Argo floats and we will evaluate both options. We have done some very basic calculations on the feasibility of a more capable generic buoyancy engine that indicate enough energy is available with a reasonable amount of batteries to meet our profiling requirements. The example below suggests that only 5 DD Li batteries would be required to provide 5 lbf of ballast (5 times the drag force at 20 cm/sec) for 150 profiling cycles (the number provided by current Argo floats) to 250 meters at 50% efficiency. Because we are adapting existing floats, minimal electrical engineering is anticipated. Somewhat more software development effort is anticipated to modify the existing UW Apex float software. Fortunately, this software has been thoroughly tested and is available as an open source product. In addition, UW has a comprehensive software verification tool suite that we hope to take advantage of. Luke Coletti has already worked with the UW Float group integrating the ISUS with the Apex float and will continue as the software/electrical engineer on this project

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$Depth_{max} := 250 \cdot m \qquad kt := 1852 \cdot \frac{m}{hr} \qquad \mu := 1.4 \cdot 10^{-3} \cdot N \cdot \frac{sec}{m^2} \qquad \rho_{sw} := 1025 \cdot \frac{kg}{m^3}$

$Pressure_{max} := Depth_{max} \cdot \rho_{sw} \cdot g \qquad Pressure_{max} = 364.473 \cdot \frac{lbf}{in^2}$

$V_{current} := 20 \cdot \frac{cm}{sec} \qquad V_{current} = 0.389 \cdot kt \qquad Dia_{piston} := 2 \cdot in \qquad ParkingForce := 5 \cdot lbf$

$$Volume := \frac{ParkingForce}{g \cdot \rho_{sw}} \qquad Volume = 2.213\,L$$

$$Length := \frac{Volume}{\pi \cdot \left(\frac{Dia_{piston}}{2}\right)^2} \qquad Length = 1.092\,m$$

$$Speed_{linear} := \frac{1 \cdot m}{2 \cdot min} \qquad Time := \frac{Length}{Speed_{linear}} \qquad Time = 131.001\,s$$

$$Force := Pressure_{max} \cdot \pi \cdot \left(\frac{Dia_{piston}}{2}\right)^2 \qquad Force = 1.145 \times 10^3 \cdot lbf$$

$$Power := \frac{Force \cdot Length}{Time} \qquad Power = 42.444\,W$$

$$Energy := Force \cdot Length \qquad Energy = 5.56 \times 10^3\,J$$

$$ElectrochemQTC_{energy} := 3.6 \cdot V \cdot 27 \cdot A \cdot hr \qquad ElectrochemQTC_{energy} = 3.499 \times 10^5\,J$$

$Eff := 0.5$

$$NumProfilesPerBattery := \frac{ElectrochemQTC_{energy} \cdot Eff}{Energy} \qquad NumProfilesPerBattery = 31.466$$

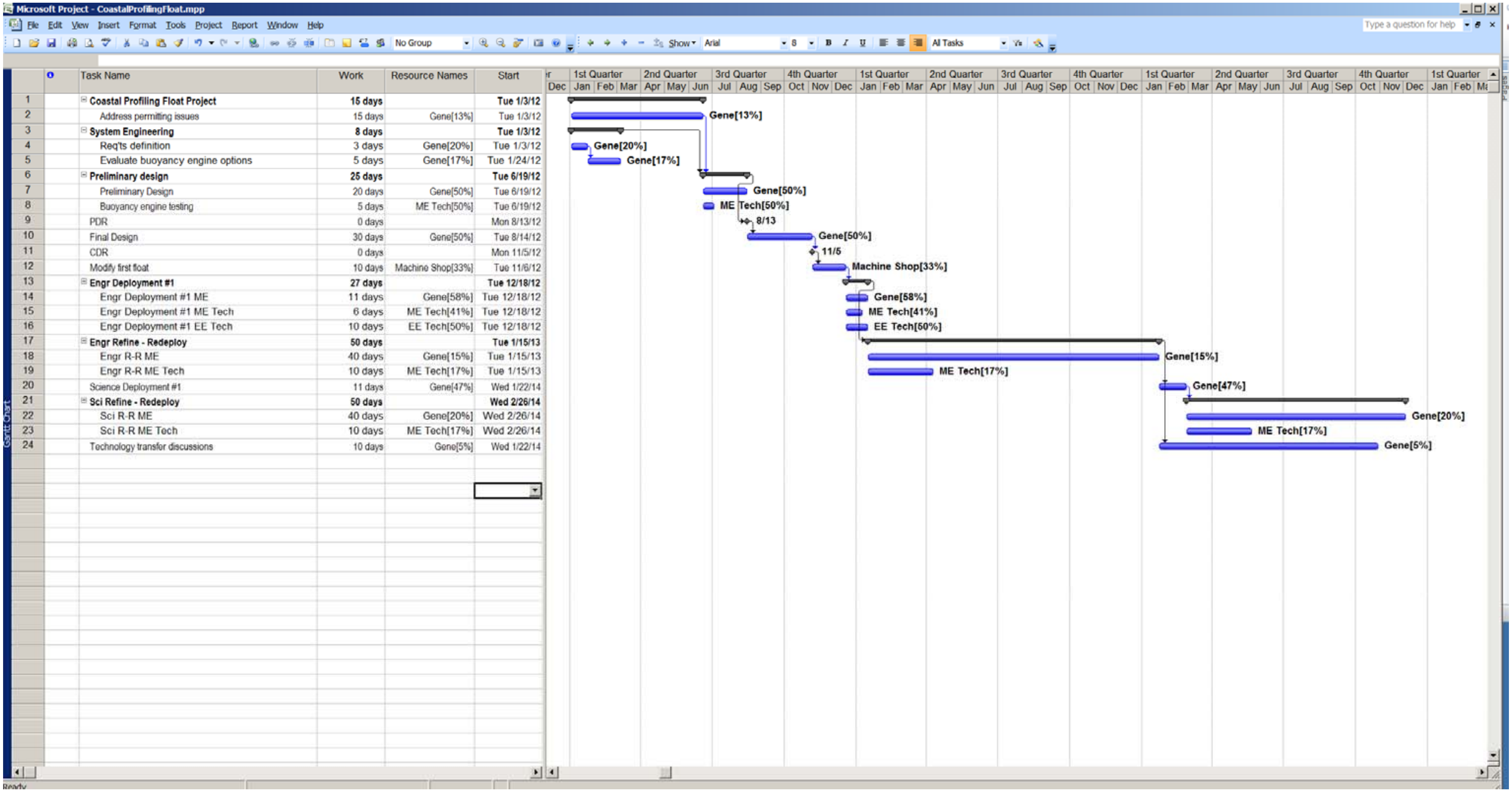
$ProfilesRequired := 150$

$$NumBatteriesPerMission := \frac{ProfilesRequired}{NumProfilesPerBattery} \qquad NumBatteriesPerMission = 4.767$$

$$\nu := \frac{\mu}{\rho_{sw}} \qquad \nu = 1.366 \times 10^{-6}\,\frac{m^2}{s} \qquad Re := \frac{V_{current} \cdot Dia_{piston} \cdot \rho_{sw}}{\mu} \qquad Re = 7.439 \times 10^3$$

$C_d := 1 \qquad Dia_{float} := 16.5 \cdot cm \qquad Length_{float} := 130 \cdot cm \qquad Area_{float} := Dia_{float} \cdot Length_{float}$

$$Drag := \frac{C_d \cdot Area_{float} \cdot \rho_{sw} \cdot V_{current}^{2.}}{2} \qquad Drag = 4.397\,N \qquad Drag = 0.989 \cdot lbf$$



	Task Name	Work	Resource Names	Start
1	**Coastal Profiling Float Project**	**15 days**		**Tue 1/3/12**
2	Address permitting issues	15 days	Gene[13%]	Tue 1/3/12
3	**System Engineering**	**8 days**		**Tue 1/3/12**
4	Req'ts definition	3 days	Gene[20%]	Tue 1/3/12
5	Evaluate buoyancy engine options	5 days	Gene[17%]	Tue 1/24/12
6	**Preliminary design**	**25 days**		**Tue 6/19/12**
7	Preliminary Design	20 days	Gene[50%]	Tue 6/19/12
8	Buoyancy engine testing	5 days	ME Tech[50%]	Tue 6/19/12
9	PDR	0 days		Mon 8/13/12
10	Final Design	30 days	Gene[50%]	Tue 8/14/12
11	CDR	0 days		Mon 11/5/12
12	Modify first float	10 days	Machine Shop[33%]	Tue 11/6/12
13	**Engr Deployment #1**	**27 days**		**Tue 12/18/12**
14	Engr Deployment #1 ME	11 days	Gene[58%]	Tue 12/18/12
15	Engr Deployment #1 ME Tech	6 days	ME Tech[41%]	Tue 12/18/12
16	Engr Deployment #1 EE Tech	10 days	EE Tech[50%]	Tue 12/18/12
17	**Engr Refine - Redeploy**	**50 days**		**Tue 1/15/13**
18	Engr R-R ME	40 days	Gene[15%]	Tue 1/15/13
19	Engr R-R ME Tech	10 days	ME Tech[17%]	Tue 1/15/13
20	Science Deployment #1	11 days	Gene[47%]	Wed 1/22/14
21	**Sci Refine - Redeploy**	**50 days**		**Wed 2/26/14**
22	Sci R-R ME	40 days	Gene[20%]	Wed 2/26/14
23	Sci R-R ME Tech	10 days	ME Tech[17%]	Wed 2/26/14
24	Technology transfer discussions	10 days	Gene[5%]	Wed 1/22/14

Figure 2

Field programs (detail ship requirements/deployments/diver requirements)
As we've described the approach is to modify the existing Argo APEX float to meet our requirements. In parallel with the development process, we need to build up an operational capability using these floats. Our plan is to deploy the 2 floats unmodified soon after delivery and all the required permits are in place in the Monterey Bay for several months. With 2 floats we can expect to continue deployments in some combination of engineering test deployments and more science driven operational deployments. 2 floats also allows for very direct comparison of the performance of varying "parking" mode techniques.

Our plan is to use MLML small boats to deploy and recover the floats. For the first year, we have budgeted for 4 deployments and 4 recoveries (8 half day operations) including 2 recoveries using the larger, more sea worthy John Martin in case we need to recover a float aiming at a MPA or other keep out area in bad weather. No diving support is anticipated for this project.

Specific deliverables

At the end of this 3 year project we expect to have 2 profiling floats optimized for deployment in coastal zones and for biogeochemical measurements with C, T, D, O_2, Nitrate and pH as the priorities. The data from appropriate deployments will be openly available on the FLOATViz web site (http://www.mbari.org/chemsensor/floatviz.htm). The goal is to have proven the capability of these profiling floats and to have started discussions with existing commercial Argo float vendors about incorporating these new capabilities in their product line.

Milestones (see last page for personnel classification list)

	Milestone 1	**Milestone 2**	**Milestone 3**	**Milestone 4**	**Milestone 5**	**Total Resources**[3] for each resource category for all milestones listed here
Milestone Date	**June 2012**	**Aug 2012**	**Nov 2012**	**Jan 2013**	**Jan 2014**	
Milestone Description	**Permitting addressed**	**PDR**	**CDR**	**1st Engr. Deployments**	**1st Science Deployments**	
EE						
SE						
ME	**15**	**28**	**30**	**51**	**61**	**185**
EE Tech				**10**		**10**
SE Tech						
ME Tech		**5**		**16**	**10**	**31**

[3] This number should be the same number you entered on the resource requests for this particular resource.

Machine Shop				**15**		**15**
Divers						

Budget justification

We've previously described the benefit of having 2 floats for evaluating various "parking" strategies and this is the majority of our budget request. We've also described the use of MLML small boats for the majority of our deployments and recoveries as well as 2 half days of John Martin time as a contingency for emergency recoveries. We are also budgeting for a small amount of electrical interface modules and material for the new buoyancy engine and new float mechanical frames. The material budget is as follows. While this is our preferred budget, some flexibility exists to move purchases into the 2nd year of the project.

Float 1	$39,000.00
Float 2	$39,000.00
Buoyancy engine prototype	$3,000.00
Buoyancy engine deployable (2X)	$5,000.00
Buoyancy test fixture	$2,000.00
Pump interface	$1,500.00
Float frame material	$2,500.00
Iridium air time	$1,000.00
Travel to UW Riser Lab (1 person 2X)	$4,000.00
MLML small whaler (6X half days)	$1,260.00
John Martin (2X half days)	$3,290.00
Misc	$1,500.00
TOTAL	$103,050.00

Project team

The project team will continue the existing collaboration between the MBARI Chemical Sensor lab and Gene Massion

Project lab space

Space will be available in the Chemical Sensor Lab for this project

Data availability outside project team, uniqueness

As mentioned earlier, appropriate data from this project will be available on the FLOATviz web site (http://www.mbari.org/chemsensor/floatviz.htm). Appropriate in this case means data which has passed some nominal data quality criteria, e.g., probably not data acquired during typical early engineering tests.

Risk matrix (development and infrastructure projects only)

	Technical Risk	Organizational Risk	Tech Transfer Risk	Labor Estimate Risk
High				
Medium	X	X	X	X
Low				

Personnel Classifications

Engineer - Mechanical Engineer (Reg)	**Engineer - Electrical Engineer** (Reg)	**Engineer - Software Engineer** (Reg)	**Engineer - Mechanical Tech** (Reg)	**Engineer - Electrical Tech** (Reg)	**Engineer - Software Tech** (Reg)	**Observ Support Technician** (Reg)	**Science – Software Engineer** (Reg)
Jim Birch (2/3)	Mark Chaffey	Dave Caress	John Ferreira	Paul Coenen	Karen S	Mike Kelley	Mike Godin
Larry Bird	Scott Jensen	Danelle Cline	Frank Flores	Tom Marion		Open - TBD	Frederic Py
Jon Erickson	Chad Kecy	Duane Edgington(2/3)	Mike Parker	Jim Montgomery			
Dale Graves (2/3)	Denis Klimov	Kevin Gomes (2/3)	Jim Schofield	Jose Rosal			
Andy Hamilton (2/3)	Paul McGill	Kent Headley (2/3)					
Brett Hobson	Ed Mellinger	Rich Henthorn					
Bill Kirkwood	Craig Okuda	Bob Herlien					
Gene Massion	Alana Sherman	Brian Kieft					
Doug Pargett		Thom Maughan					
Farley Shane		Mike McCann					
		Rob McEwen					
		Tom O'Reilly					
		Wayne Radochonski					
		Mike Risi					
		Brent Roman					
		Carlos Rueda-Velasquez					
		Brian Schlining					
		Rich Schramm					