Development of a Next Generation Platform and Instrumentation for Continuous Ocean Observations (PICO) for Reducing the Costs of Observations

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1. Project Summary

The purpose of developing a Platform and Instrumentation for Continuous Observations (PICO) is to advance the state of NOAA’s open ocean observation systems with the development of an easy-to-deploy and low-cost mooring system that makes use of novel buoy technology and commercially available sensors and instrumentation (www.pmel.noaa.gov/pico). This Next Generation Climate Observation project is developing low-cost/high quality modular components of moored ocean sensor platforms to enhance and eventually replace the tropical moored arrays that are a cornerstone of the climate observing system.

A new element of this system is the PRAWLER (Profiler + Crawler) mooring development, which will strengthen our moored sampling capability by producing well-resolved vertical profiles (an advance over the present few discrete samples), and adding reliable and routine salinity sampling to the suite of measurements. The sampling is also reconfigurable in real time, allowing adjustment for process studies, responses to storms or marine disasters, and power management. The PRAWLER uses almost no battery power for locomotion and has a heave energy conversion rate of ~80%; that is, for every 1 m of wave heave, the PRAWLER climbs 80 cm. All sampling is done during descent at user-defined intervals and all data is returned in real time. The value is significant cost reductions and improved data that can be made with a single profiling instrument, as opposed to ~12 individual sensors on a mooring line. The smaller mooring is easier and safer to deploy and maintain. These advancements are improving both cost and performance for tropical moorings.

A Saildrone autonomous vehicle is being outfitted with surface MET and subsurface instrumentation. Phase 1 in FY’14 included signing a CRADA (cooperative research and development agreement), starting procurements and integration of surface sensors.

Users of this technology include: 1) ocean and atmospheric researchers and program managers studying ENSO, etc; and 2) scientists and engineers who are evaluating the quality and
endurance of the PRAWLER moorings for possible future inclusion in the Tropical Moored Array and commercial viability. We are following the 10 GCOS Climate Monitoring Principles and will complete side-side comparisons with reference instrumentation.

2. **Scientific and Observing System Accomplishments**

This project develops, brings to readiness, and deploys new technology for ocean profiling. The main development in FY’14 was a PRAWLER (Profiler + Crawler) deployment in high currents at 2N 155W and 5N 155W that were designed to profile between selectable ocean depths (typically from 3m to 450 m). All sampling is done during (free-falling) descent at user-defined intervals and all data is returned in real time. The PRAWLER presently incorporates a newly commercialized Seabird PRAWLER pumped CTD, but in future years could include a micro-current meter or bio-geochemical sensors such as DO, pH. As part of another proposal we’ve built and deployed a Carbon PRAWLER with a DO sensor and have procured Nortek Aquadopps as part of the COD FY’14 proposal.

The 2N and 5N 155W moorings included sonic wind speed and direction, SST, a newly developed AT/RH passive aspiration plates and a loadcell on each buoy. All data are returned in realtime.

a. How did your project deliverables serve the observing system’s program deliverables?

This year’s deliverables included technology innovations for moored and autonomous systems to help meet the program’s deliverables of high quality, low cost observations for:

- Sea Surface Temperature and Surface Currents
- Ocean Heat Content and Transport
- Air-Sea Exchanges of Heat, Momentum, and Fresh Water

and the specific societal challenges addressed include:

- Reduce vulnerability to extreme weather (extremes);
- Prepare for drought and water resource challenges (drought);
- Manage risks to coastlines and coastal infrastructure (coastal inundation)

b. What did you achieve during FY 2014?

The deliverables for FY 2014 include:

**PRAWLER Deployments**

(a) Deploying and operating two mooring PRAWLER moorings at 2N 155W and 5N 155W. Data collected include:
This year’s goal was the end-to-end field testing of the PRAWLER hardware and software with two different mooring designs in the equatorial Pacific. The effort builds on the successful deployment in the Atlantic as part of the SPURS experiment and includes the same SPURS PRAWLER design.

Unfortunately, we had mixed results in high current locations. While all sensors on the buoy performed well, the PRAWLERs experienced problems within days of deployment. The 5N PRAWLER made ~10 profiles and then got stuck at the bottom at 450m and the 2N made 185 profiles but was not reporting CTD data and got stuck at the top (3m) after 12 days. We believe the problem is in the coil mechanism that reverses the direction of the pawl and have changed this mechanism in our Carbon PRAWLER vehicle because of magnetic variations in the coil and the large amount of labor required for proper tuning of the coil/magnet. The new mechanism has some additional advantages for sampling on mooring lines including: 1) ease of manufacture compared to hand wound coils, 2) a park feature to hold at specified depths to mitigate bio-fouling and to conserve power compared to the previous version that was always moving, 3) the potential to climb
downward in locations of high currents where free falling is insufficient to reach the bottom.

The profiles that were completed (Fig 2) also showed that the PRAWLER was moving very slowly or stopped moving on some of the profiles between 70-100m. This coincides with the maximum currents at each location as shown from the R/V Kilomoana ADCP (Fig 3). We now believe we have a solution to overcoming strong currents by adapting our mechanism to allow for downward ratcheting when the currents exceed a threshold that allows for free-descent. See Figs 5-6.

![Fig 2: Sample PRAWLER Profile from 5N 155W](image)
Red squares are from TAO buoy Temp sensors deployed 23km away

![Fig 3: ADCP Currents July’14 from R/V Kilomoana ADCP](image)
PRAWLER Current Meters
(b) Aquadopp current meters were specified and procured in late FY’14 and will be tested in Puget Sound in FY’15. We believe the park and hold mechanism will provide an excellent mechanism to test free descent and ‘parked’ measurements. Initial looks at power consumption look promising towards achieving long endurance (~6 month) missions.

Saildrone
(c) The Saildrone is an unmanned, self-righting vehicle that has a payload capacity of ~100kg and ~80W of solar panels. The vehicle has a mast height of 4m and keel of 2m, making it well suited for ocean observations. A prototype (no MET sensors) vehicle sailed from San Francisco-Hawaii-Palmyra-Hawaii with over 100 DAS, 5873nm with an average speed of 2.5kts.

In FY’14 PMEL signed a CRADA (Cooperative Research and Development Agreement) to develop and integrate sensors for ocean research onto the Saildrone platform. Phase I of the integration included: 1)Wind, 2)Atmospheric Temperature and Relative Humidity, 3)IR SST, 4)PAR and 5)Barometric pressure. Test missions were flown in San Francisco Bay and meta data including IMU and compass are being integrated with the MET measurements (Fig 4).

![Saildrone Phase I Sensor Integration](image)

Fig 4: Saildrone Sensors Integrated in FY’14
c. What scientific advances were made and/or facilitated through your activities?

PRAWLER

The key advancement made this year is the real-world, end-to-end testing of the PRAWLER hardware and software in a scientific experiment, co-located with TAO moorings that will enable checking and validation of the technology.

We’ve learned that free-decent of a PRAWLER on a mooring line is marginal in high current areas and that an upward and downward cam mechanism could be well-suited for such areas. We have built a prototype with some of these features and tested in Puget Sound with excellent results.

Fig 5: New PRAWLER Cross-sectional view
Saildrone
The key advancements made this year are 1) Signed CRADA and 2) Integrating surface MET instrumentation on Saildrone, an autonomous surface vessel. While missions without sensors have gone ~100 days and >5000nm, this is the first effort made to incorporate high quality measurements for climate observations and test them in the highly variable conditions of San Francisco Bay.
d. What is the significance of these advances?

We have shown a proof of concept of this alternative and complimentary technology that expands the suite of ocean observing technology to researchers, including moorings and autonomous vehicles. CTD (and other sensor) profiles offer researchers an adaptive profiling tool rather than a few fixed discrete-level measurements as are now used within the mooring arrays. These advancements are improving both cost and performance for tropical moorings.

The few profiles made in 2014 at 2N and 5N have shown that a slightly different technology is needed in high current regimes (as compared to SPURS), to ratchet up and down in order to overcome the drag on the mooring line. While further testing is needed, we feel optimistic that this concept can work effectively on the equator, harvesting wave energy for both the upward and downward cast and giving researchers a flexible and cost effective tool.

e. What, if any, information was jeopardized due to a lack of funding, lack of instrumentation, or inability to carry out the work?

The delay in funding from the beginning of the FY, means that ship planning and field work is difficult to schedule and commit to. This leave the potential of abandoning the 2N and 5N, 155W moorings/sensors and high resolution data because of lack of funding, jeopardizing the R&D timeline.

f. What is the web site for your program?

www.pmel.noaa.gov/pico. Data from SPURS is currently being evaluated by Dr. Billy Kessler and other SPRURS researches with data made available on the SPURS website. Publications are in process. The MET and profile data from the 2N, 155W and 5N, 155W buoys are stored on internal servers and engineering developments can be seen at: http://pmel.noaa.gov/edd/.

For projects involved with data collection, please address the following questions:

a. Are your data distributed in real time on the Global Telecommunications System?

As this is a technology development project, the data are not distributed in realtime via the GTS.

b. Where do your real time data reside? Are the data available online?

The data are available in realtime on an internal PMEL server and are currently being compared to TAO buoys at 5N 155W and 2N 155W.
c. Where do your delayed mode data reside? Are the data available online? What is the date of the most recent data available publicly?

In case of telecoms failure all data are backed up on-board the PRAWLER and will be evaluated once the systems are recovered. PRAWLER data will be shared via the SPURS website and made publicly available.

d. Where are your data archived and with what frequency?

N/A

e. What is the web site where the data for your program can be accessed? If you haven’t updated your web site recently, please do so now.

http://ferret.pmel.noaa.gov/spurs/UI.vm

f. Have you successfully retrieved your program’s data from the website or Data Assembly Center where your data reside, just to ensure the accessibility of the data?

N/A

g. Do you have a data management plan for the data collected as part of your project? If so, list the url where the data management plan can be found.

N/A

3. Outreach and Education

Results from this work were briefed by Chris Meinig to Dr. Sullivan, Craig Mclean and Sen Begich and Cantwell in August 2014 and also made local NPR radio and local news. PRAWLER developments were also presented at the ONR/MTS Buoyworkshop in San Diego in March 2014.

Meinig also presented a talk on Emerging Technology, with co-authors Rudnick, Send, Riser, Ando, Suga at the TPOS meeting in San Diego in Jan 2014, that included technology developments from these PMEL projects, funded by COD.

Education and outreach was primarily accomplished thru an updated website www.pmel.noaa.gov/pico and thru PMEL Engineering Buoy YouTube channel: http://www.youtube.com/playlist?list=PLE575643A95F6CED2&feature=plcp

International collaborations included outreach and training to Chinese, Japanese, Indian and Australian engineers and scientists. Additionally ~10 tours and a NOAA WRC Open House were given to the general public highlighting NOAA developed technology, including PICO and PRAWLER.
4. **Publications and Reports**

There were no peer-review publications during this reporting period, but several are in process from the SPURS data set.