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Profiling Floats and Gliders/AUVs Powered by Ocean Temperature Differential

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Unmanned Undersea Vehicles (UUVs)

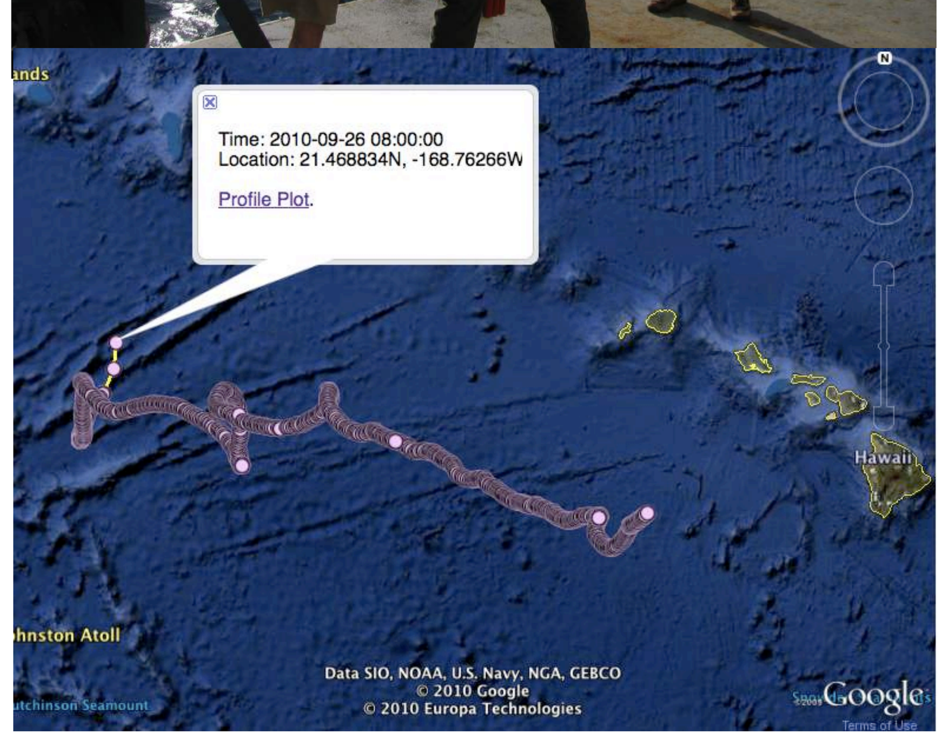
The fundamental observational problem in oceanography is that of sampling a global, turbulent fluid with physical, biological, and chemical processes that are active over a wide range of scales. During the last decade, oceanography has witnessed a revolution in observing capabilities such as UUVs (e.g., floats, gliders, or AUVs).

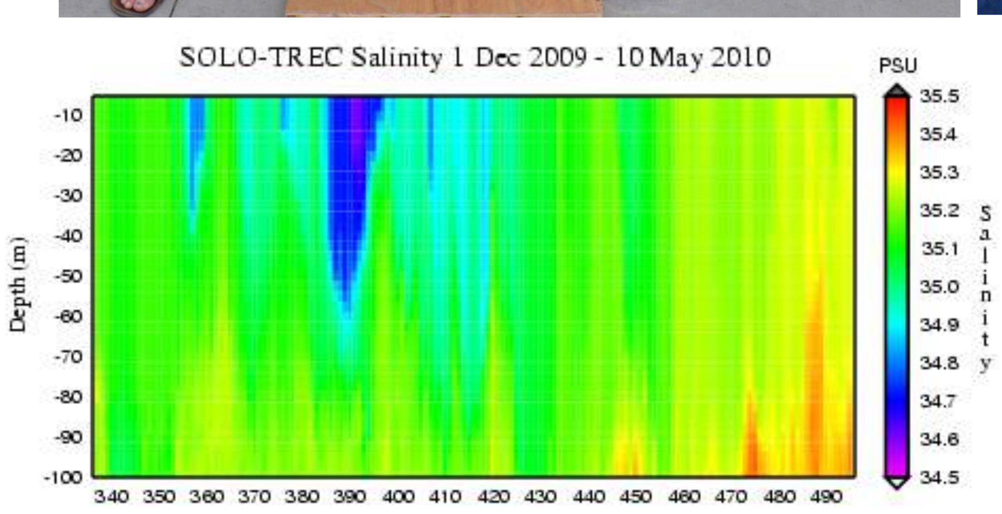
Ocean Thermal Energy: Unlimited Energy Supply for UUVs

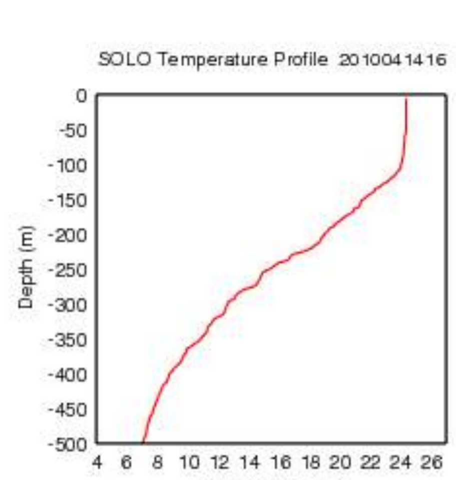
Long endurance, high speed, and high payload power all require increased energy capacity on the UUV. Energy considerations ultimate will impact vehicle design, size, and type. Furthermore, there are disadvantages to using the conventional battery technologies for UUVs. The primary batteries have to be discarded after use, and the cost penalty for batteries can be high for large UUVs. High energy density batteries (e.g., lithium batteries) introduce safety concerns. Rechargeable batteries are less costly over time. However, replenishment or recharge of batteries (especially at-sea) is a major issue for UUV operations that require rapid reconfigurability and may not be practical in many applications.

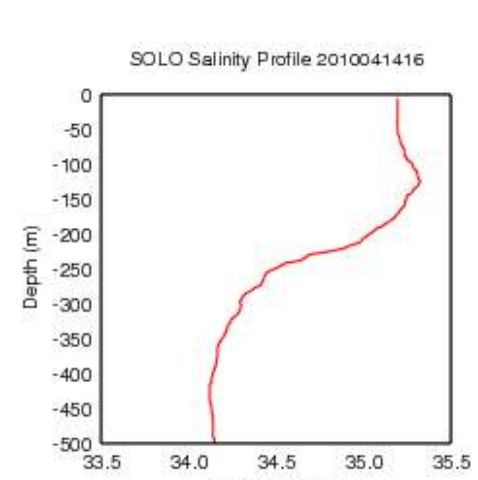
Prototype Demonstration: TREC Powered SOLO Float

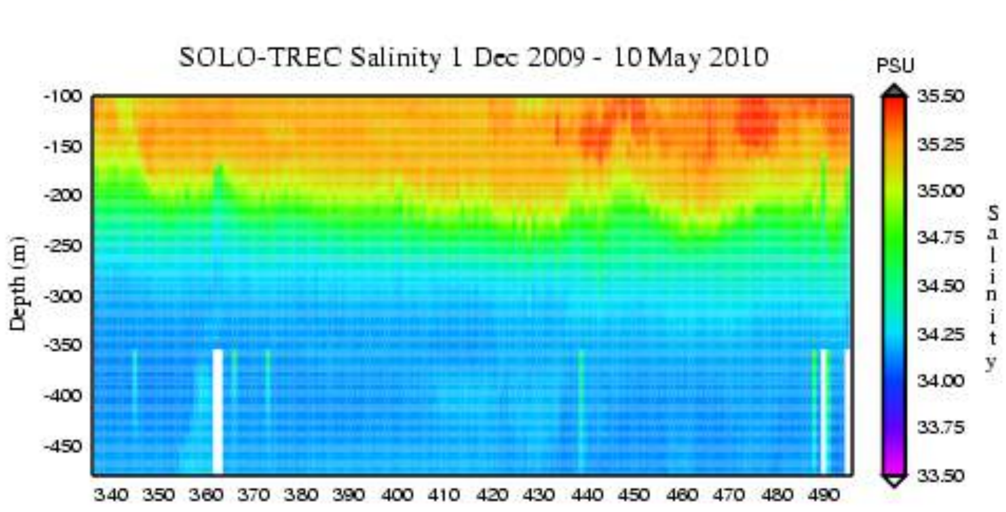
We have designed a modified SOLO float so that the recharging batteries, and thus the buoyancy control and all electrical operations, are powered by drawing the thermal energy from the temperature differences between the warm upper ocean and the colder depths. A SOLO-TREC prototype was deployed on Nov. 30, 2009, about 161 kilometers (100 miles) southwest of Honolulu. Since its deployment, SOLO-TREC has been making 3 dives per day between the surface and 500 meters depth. PCMs on-board the SOLO-TREC expand about 13% when heated above 10°C and then correspondingly contract when cooled below 10°C. This expansion/contraction produces a high pressure oil that can be collected and periodically released to drive a hydraulic motor for electricity generation and battery recharging of about 1.6 Watt-hours (or over 7000 Joules) each dive. By June 2011, SOLO-TREC has made more than1000 dives between surface and 500 meters.







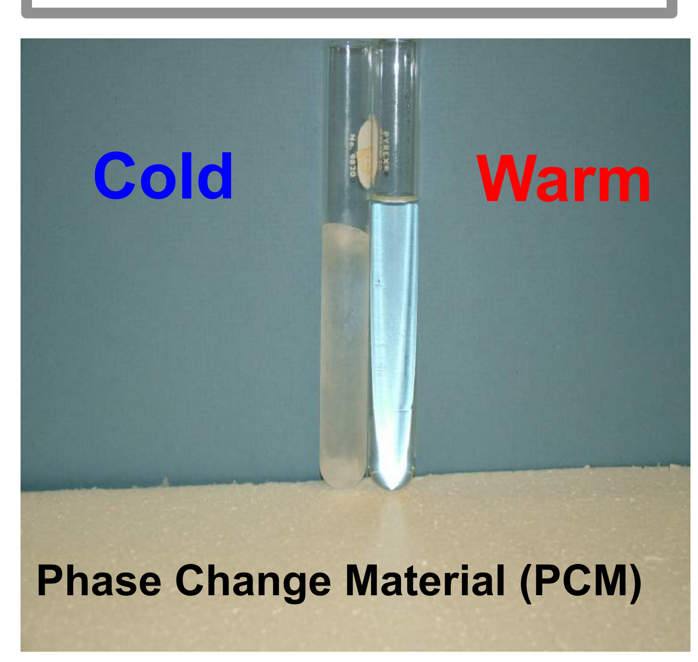


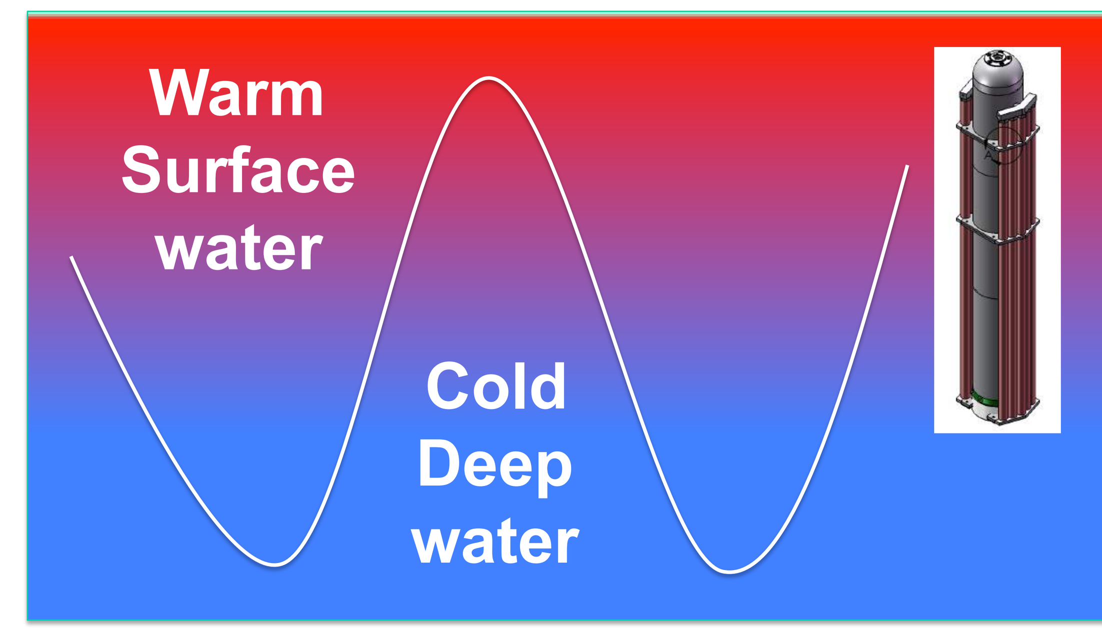


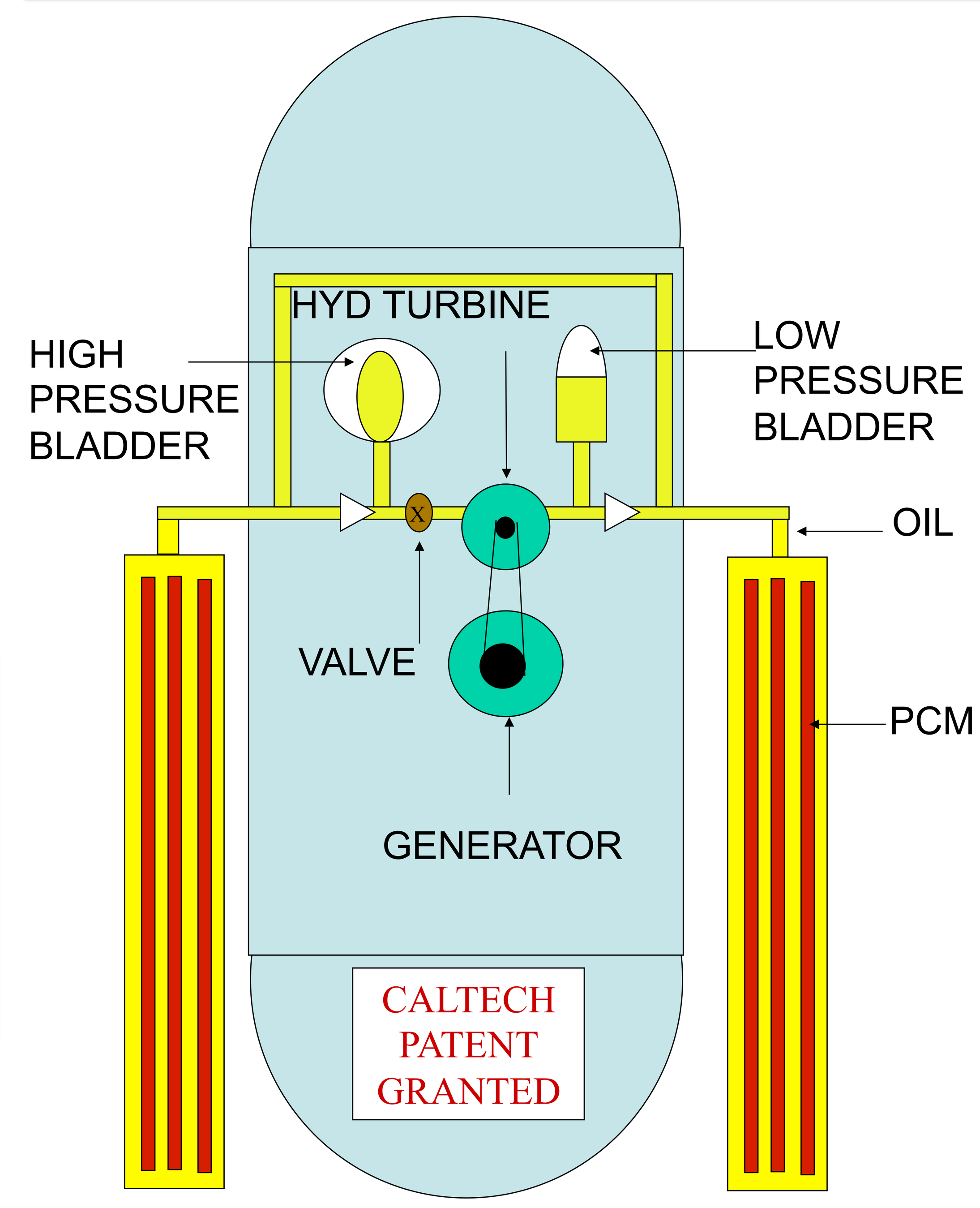
Picture of SOLO-TREC float and its deployment. Examples of science data: vertical profiles of temperature salinity and depth-time plot of salinity in the upper 100 m (top) and 100-500 m (bottom).

Thermal RECharging (TREC) Battery

We have developed a commercially available Phase Change Material (PCM) wax with a phase change temperature of 10°C, which can be melted at sea level, and frozen at deeper ocean depths. The primary novelties of our approach are to use advanced materials and heat transfer designs to generate a high pressure fluid that drives a hydraulic motor/generator to charge the batteries. This power cycle requires only a small temperature difference above and below a given material's phase change temperature of about 10°C, which can be adjusted with different mix of PCMs.

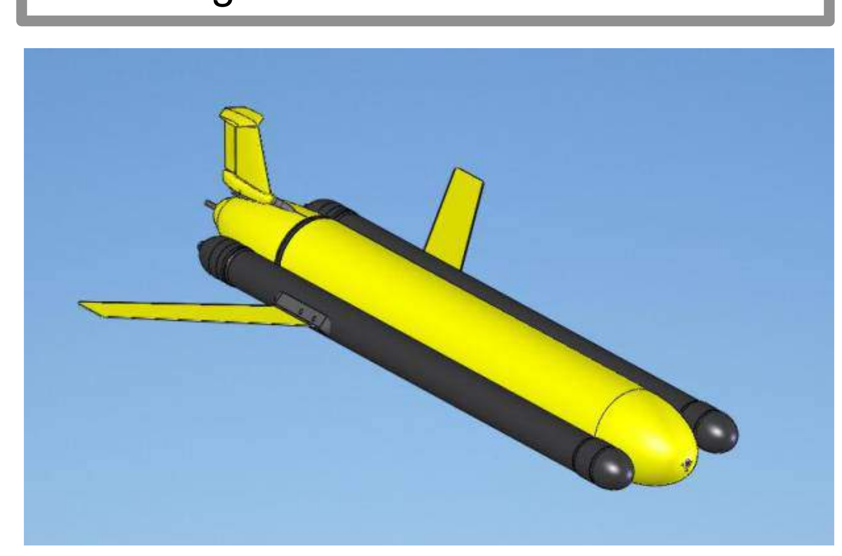






Next-Generation: TREC Powered Underwater Glider

The TREC battery can also be used to power underwater gliders so as to increase its endurance and power more energy-demanding sensors. This is complementary to the existing electric gliders powered by primary batteries that have been used widely since their first successful ocean tests more than a decade ago.



Future Generation: TREC Powered Underwater Charging Station

AUVs have a high payload capacity relative to floats or gliders, and will carry a suite of sensors for interdisciplinary observations. However, AUVs have a much shorter lifetime, and therefore requiring ship support for recovery, battery replacement/recharging and redeployment. The TREC battery can be used to power an anchored docking station onto which AUVs can dock and recharge its batteries.