

利用固定平台及自主水下航行器 实现自适应海洋观测

(Adaptive Ocean Observation

Using Fixed Platforms and Autonomous Underwater Vehicles)

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Outline

- Review of adaptive signal processing
- Adaptive ocean observation
 - Moorings
 - Autonomous underwater vehicles (AUVs)
- Prospect of an adaptive ocean observing system
- Summary

The Start – Adaptive Signal Processing

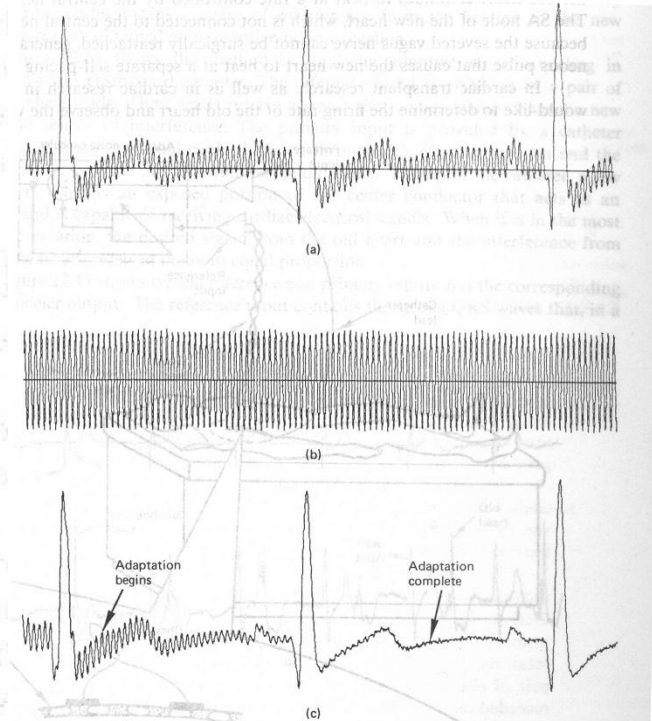
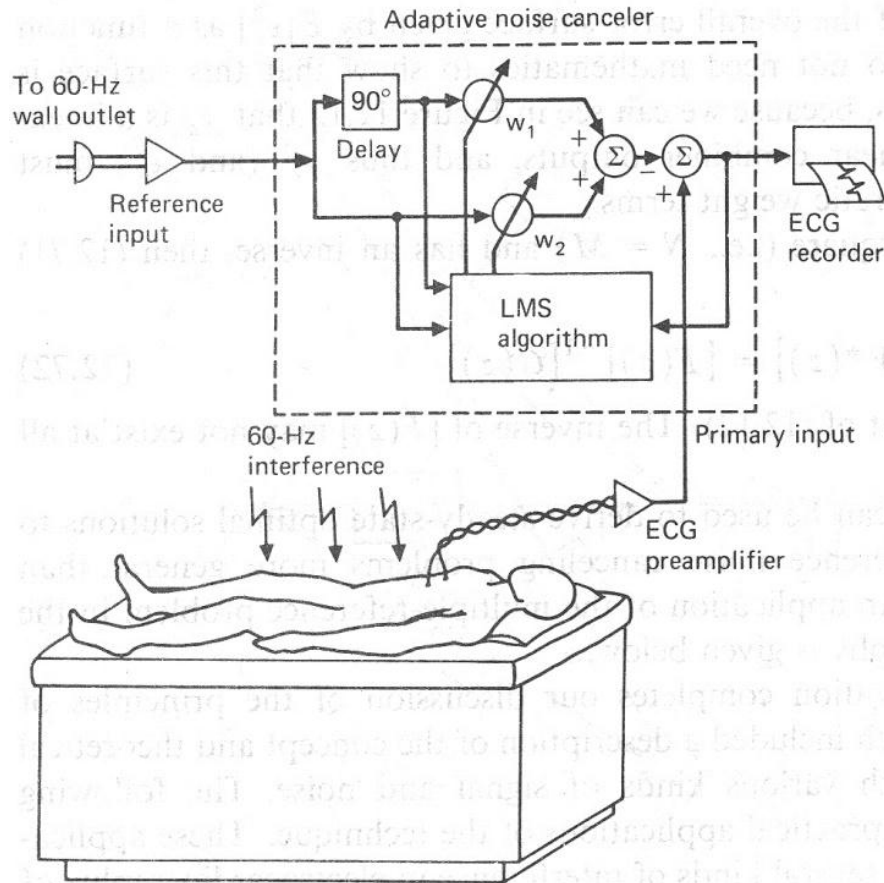


Figure 12.15 Electrocardiographic noise canceling: (a) primary unit; (b) reference input; (c) noise canceler output. From B. Widrow et al., *Adaptive Noise Canceling: Principles and Applications*, © December 1975, IEEE.

Into the Ocean – Adaptive Sampling of Oceanographic Signals

- Increasing sensors' sampling rate when some oceanographic event is detected, e.g., on detection of internal waves.

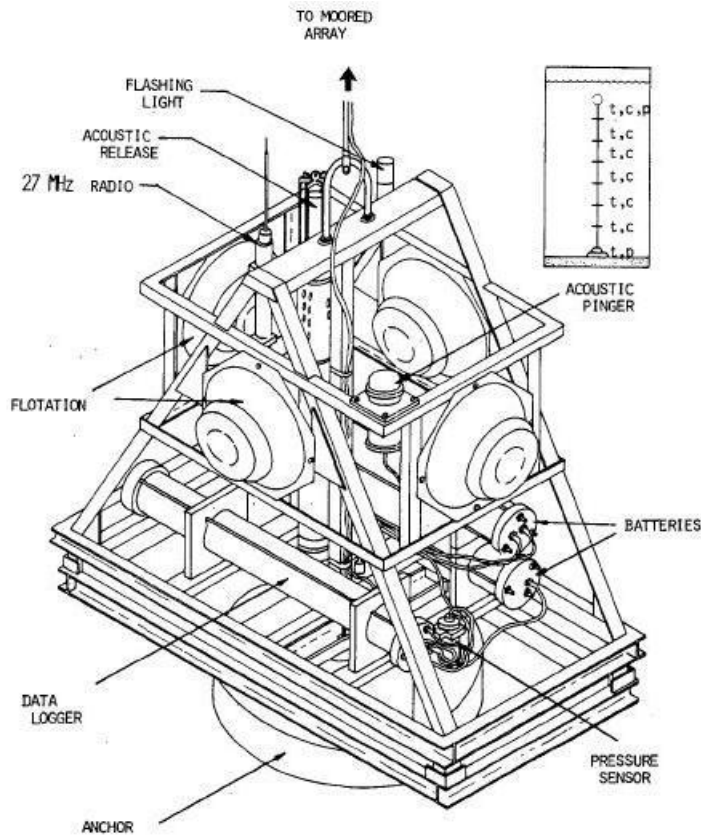
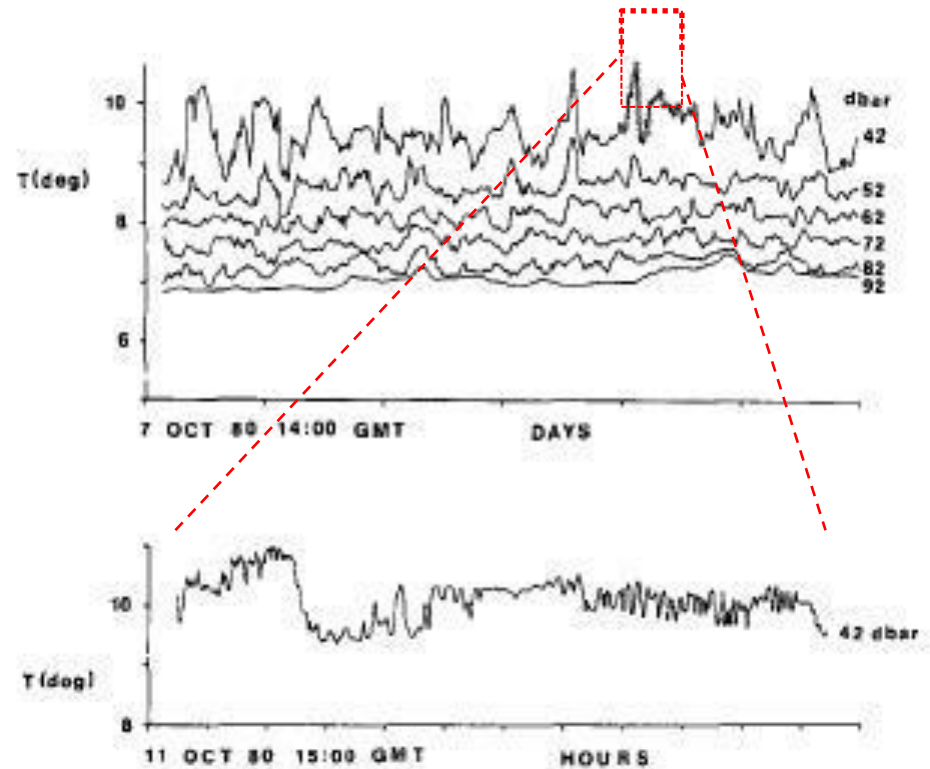


FIG. 2. UNH bottom-mounted instrument.



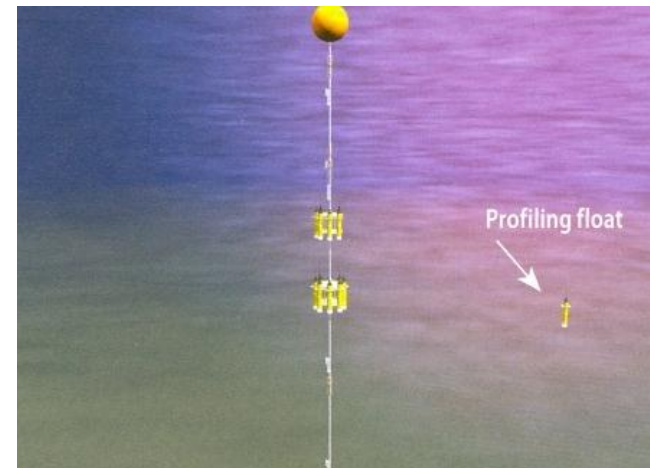
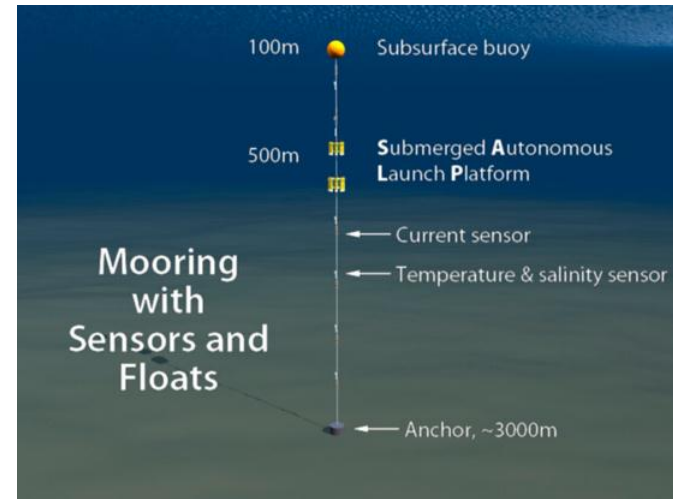
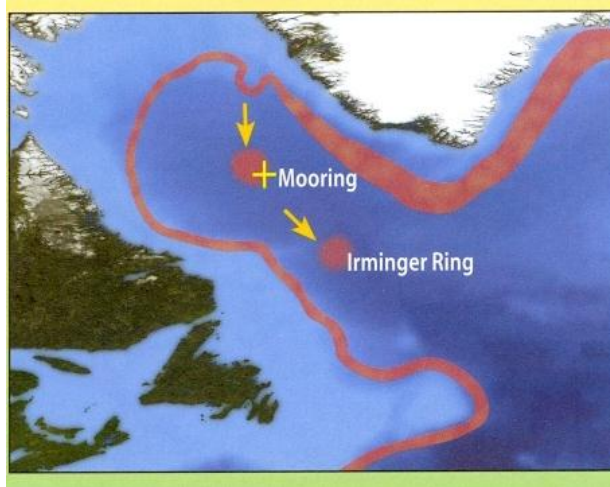
From [Irish et al., *Journal of Atmospheric and Oceanic Technology*, 1984]

Ocean Observation

- 固定平台
 - 长处: 长时间、不间断监测。
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An Adaptive Mooring – Submerged Autonomous Launch Platform

- Releasing profiling floats from a mooring when a warm eddy passes by.



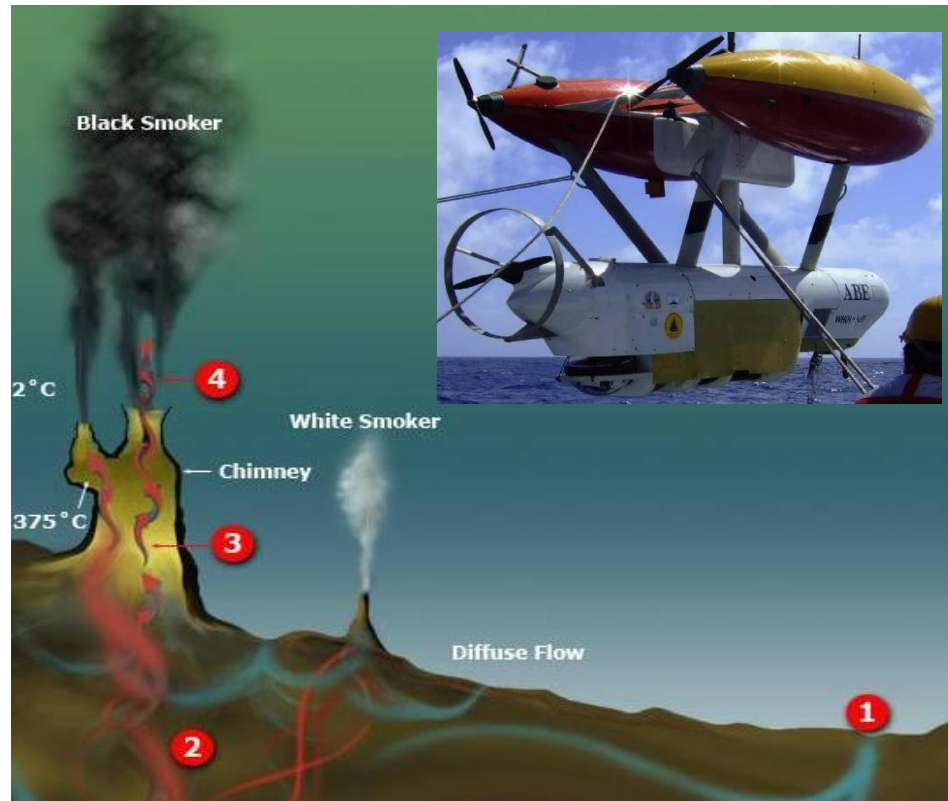
From Woods Hole Oceanographic Institution (WHOI) *Oceanus Magazine*, Vol. 46, No. 2, 2008, and [Bower et al., 2009]

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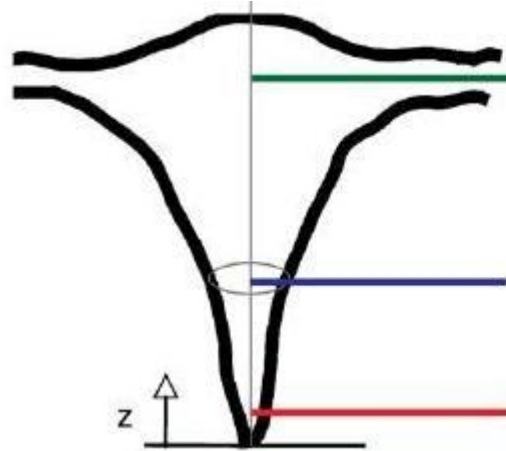


Autonomous Underwater Vehicles (AUVs) in Ocean Observation

1. Searching for hydrothermal vents



WHOI ABE AUV's 3-phase search for hydrothermal vents

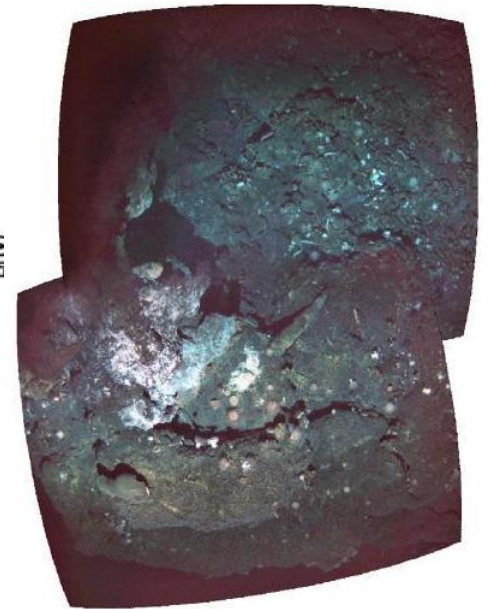
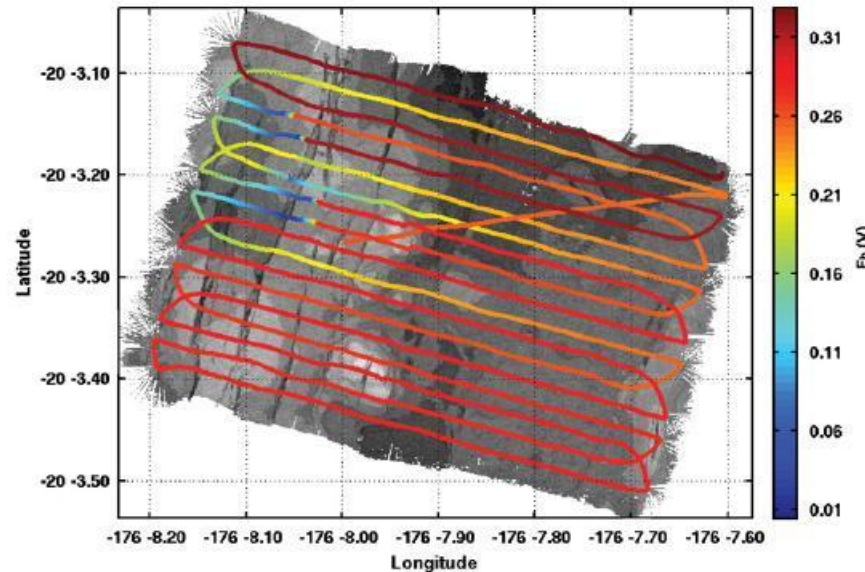
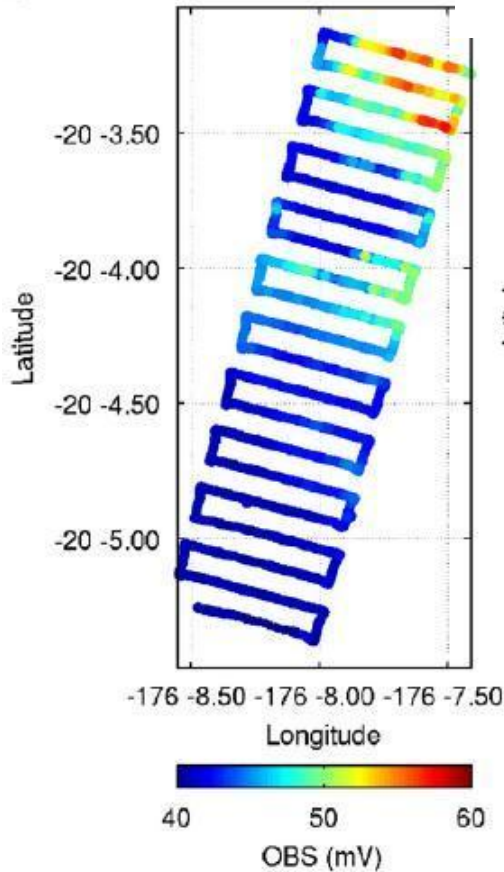


Phase 1: Mapping the non-buoyant plume using Eh and Optical Back Scatter sensors.

Phase 2: SM2000 multi-beam mapping and intercepting buoyant hydrothermal plumes.

Phase 3: Seafloor sensor and photo surveys

a



From [German et al., *Deep-Sea Research I*, 2008]

Adaptive Ocean Observation

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- 自主水下航行器

- 长处：大范围游动搜索。
- 短处：无法对空间点不间断监测，知此时不知彼时。

观测 – *何时何地？*

追踪 – *何去何从？*

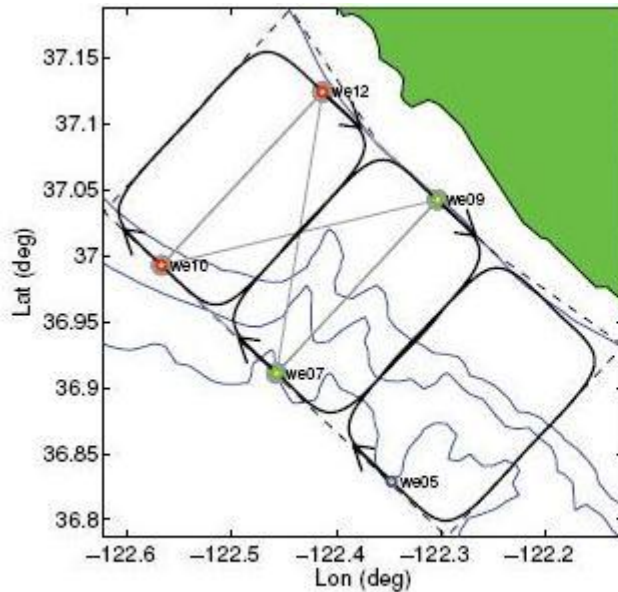
2. Adaptive fleet control of gliders



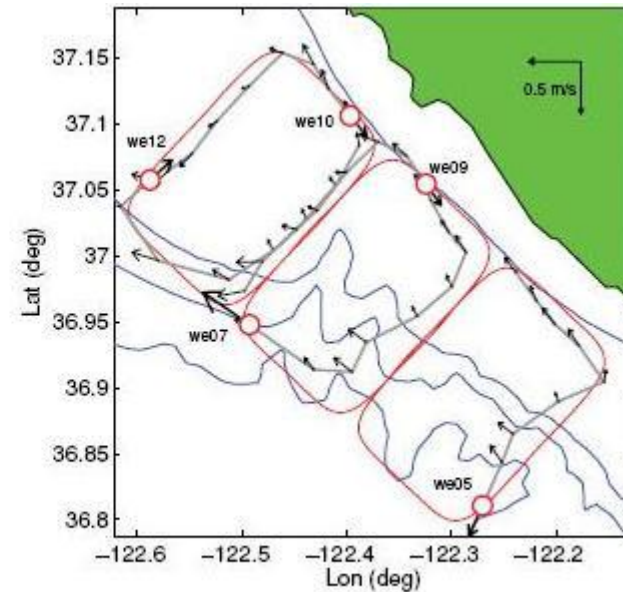
(a) Slocum glider



(b) Spray glider



(a) ASAP GCT 6



(b) Glider trajectories, 6:00 GMT August 4

From [Leonard et al., *Journal of Field Robotics*, 2010]

3. Adaptive sampling and tracking of an upwelling front

SST (°C)

11

12

13

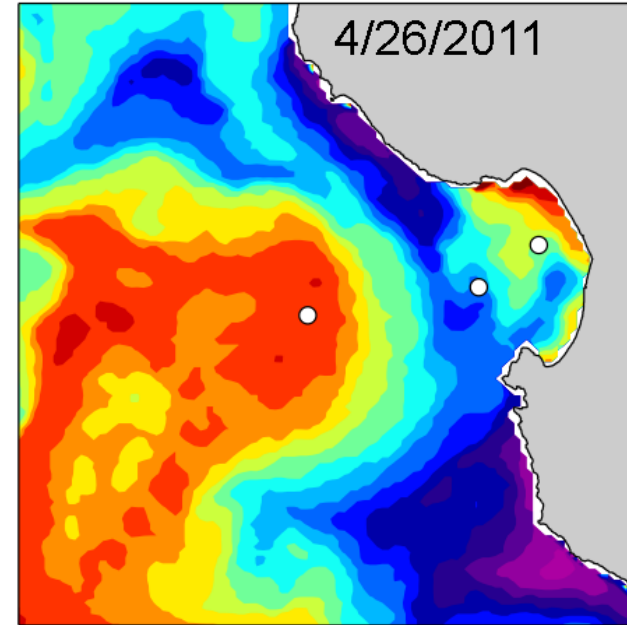
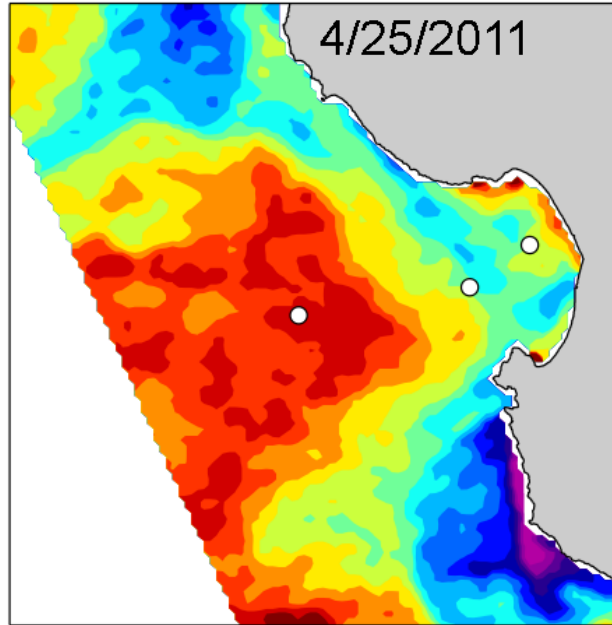
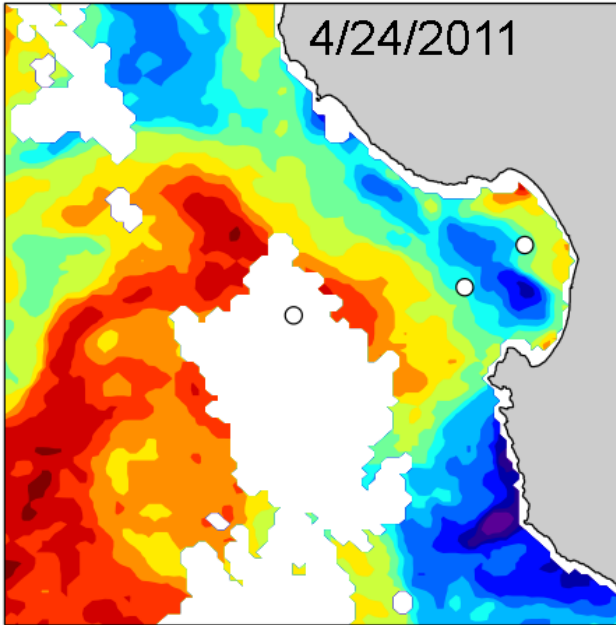
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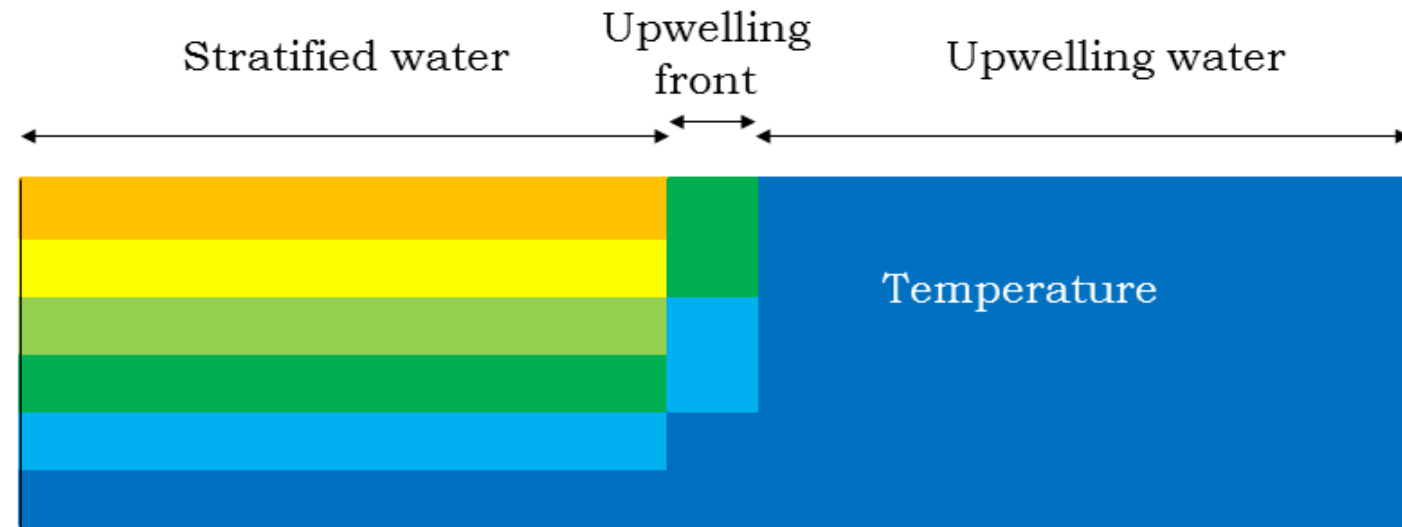
4/24/2011

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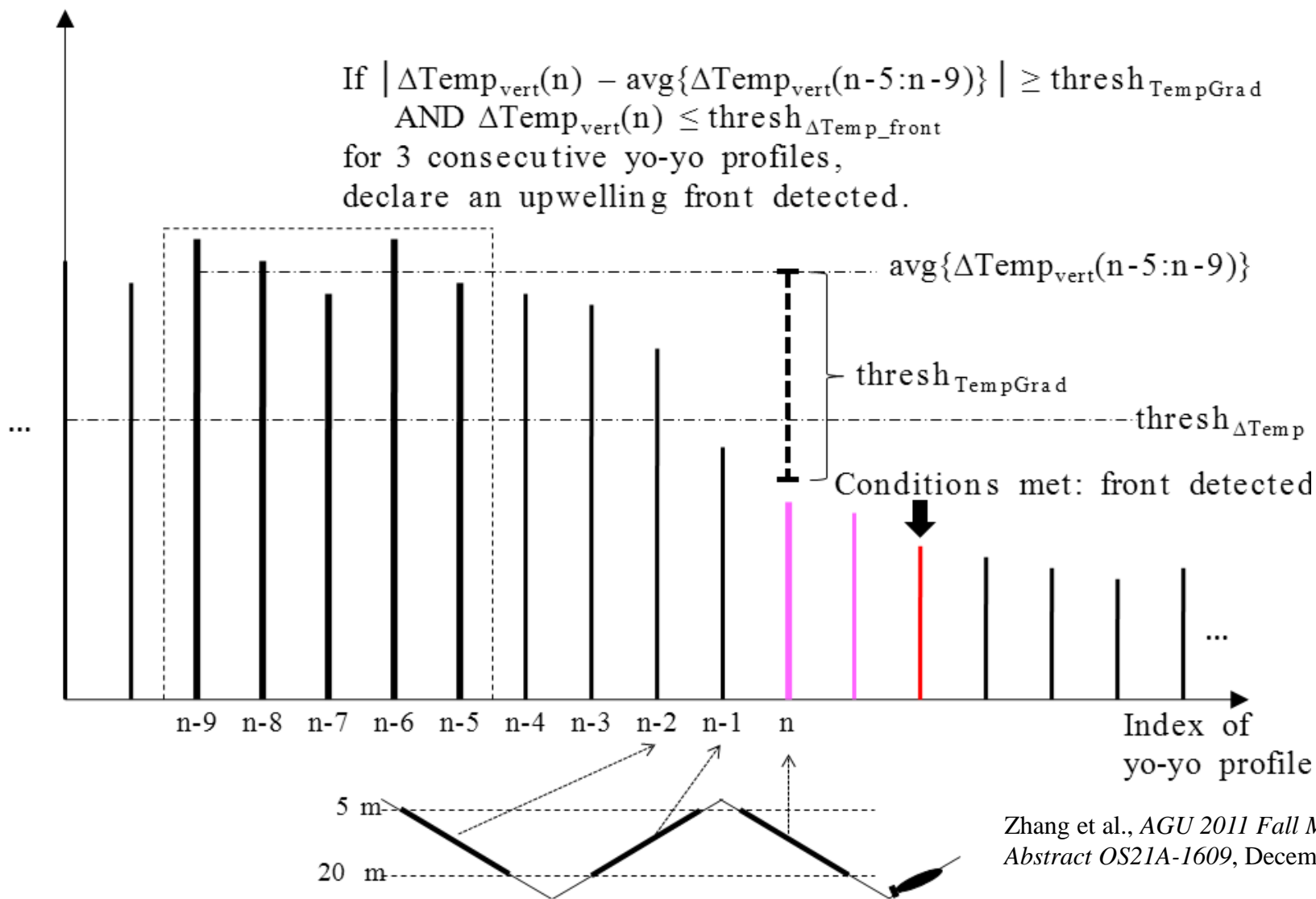
Distinguishing between upwelling water and stratified water



AUV algorithm for detecting the upwelling front

$\Delta\text{Temp}_{\text{vert}} = \text{Temp}_{5\text{m}} - \text{Temp}_{20\text{m}}$ on each yo-yo profile

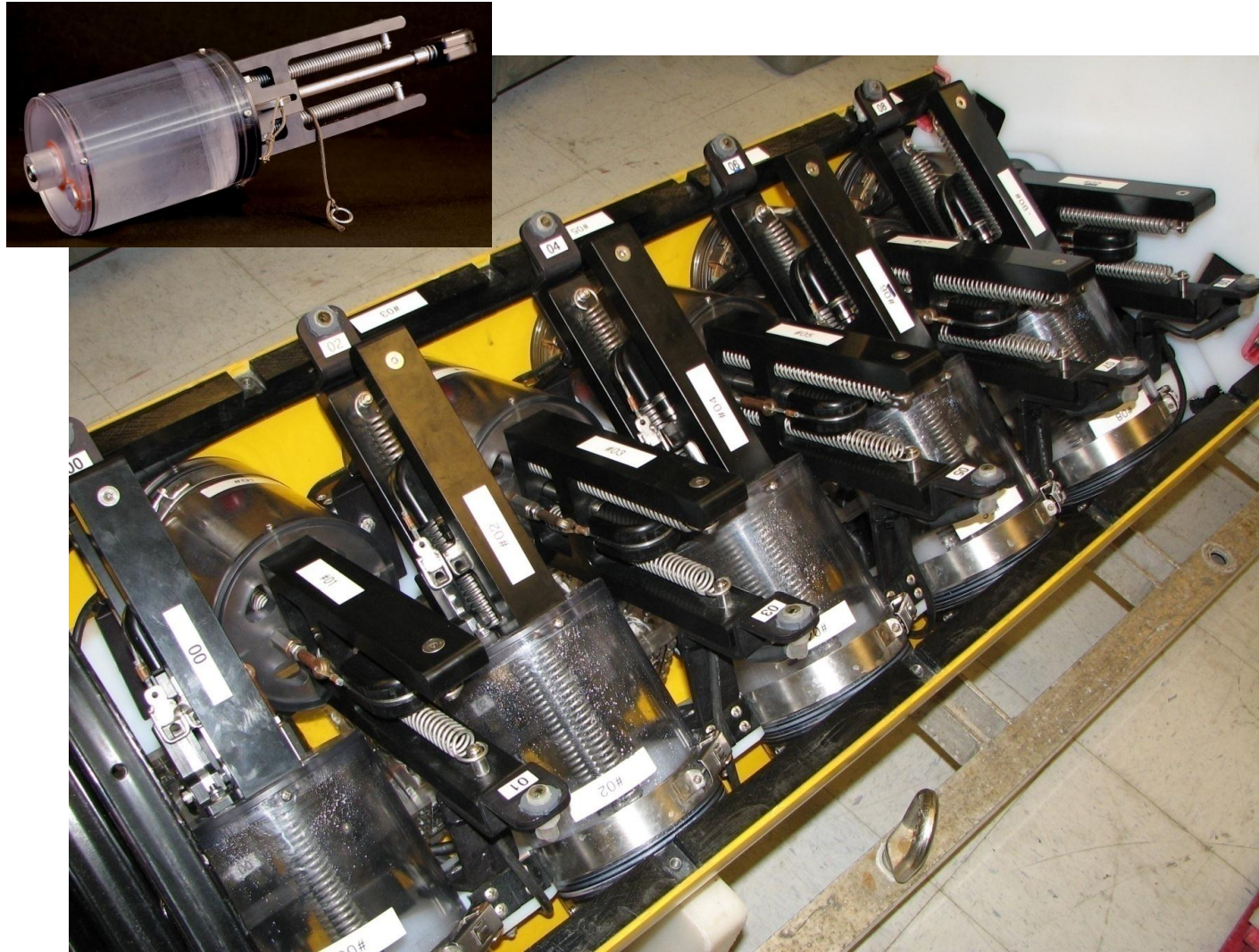
If $|\Delta\text{Temp}_{\text{vert}}(n) - \text{avg}\{\Delta\text{Temp}_{\text{vert}}(n-5:n-9)\}| \geq \text{thresh}_{\text{TempGrad}}$
 AND $\Delta\text{Temp}_{\text{vert}}(n) \leq \text{thresh}_{\Delta\text{Temp}_{\text{front}}}$
 for 3 consecutive yo-yo profiles,
 declare an upwelling front detected.



Zhang et al., *AGU 2011 Fall Meeting Abstract OS21A-1609*, December 2011.

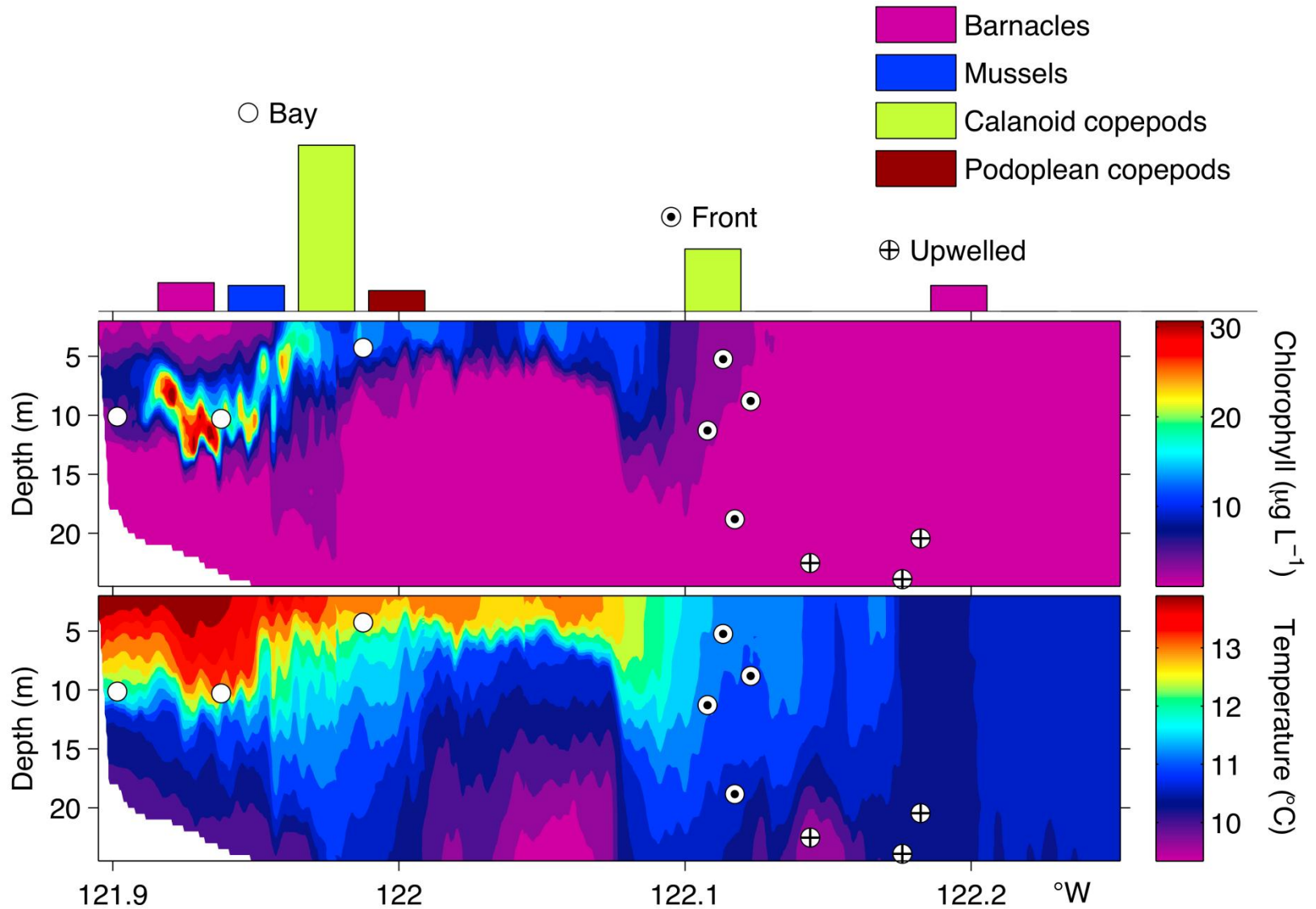
Zhang et al., *Limnology and Oceanography: Methods*, in press.

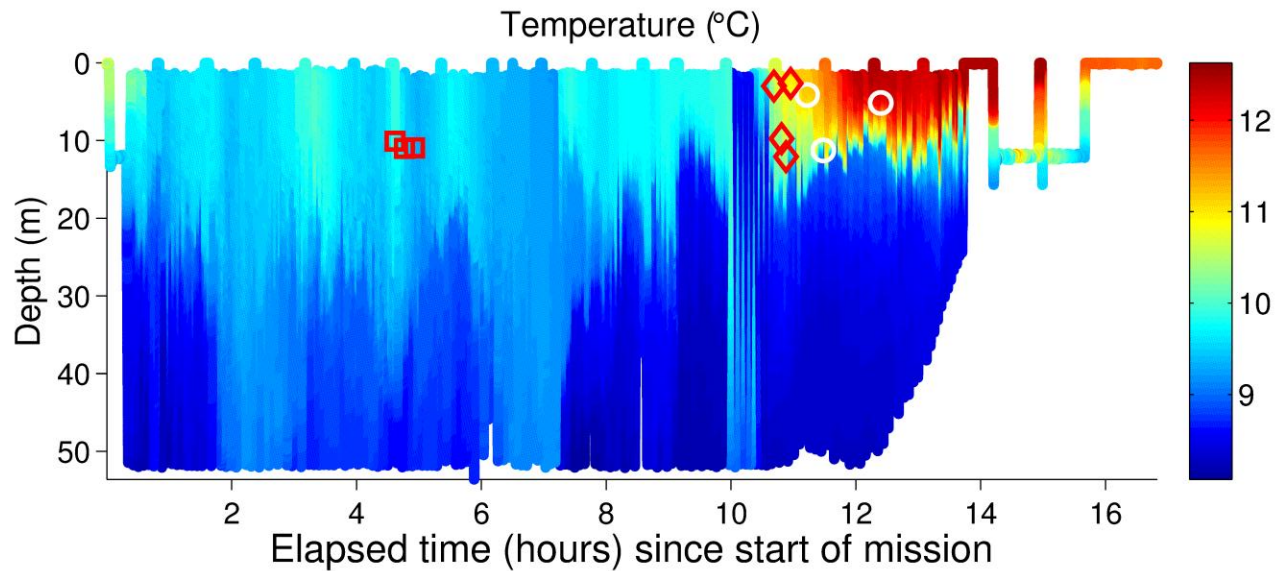
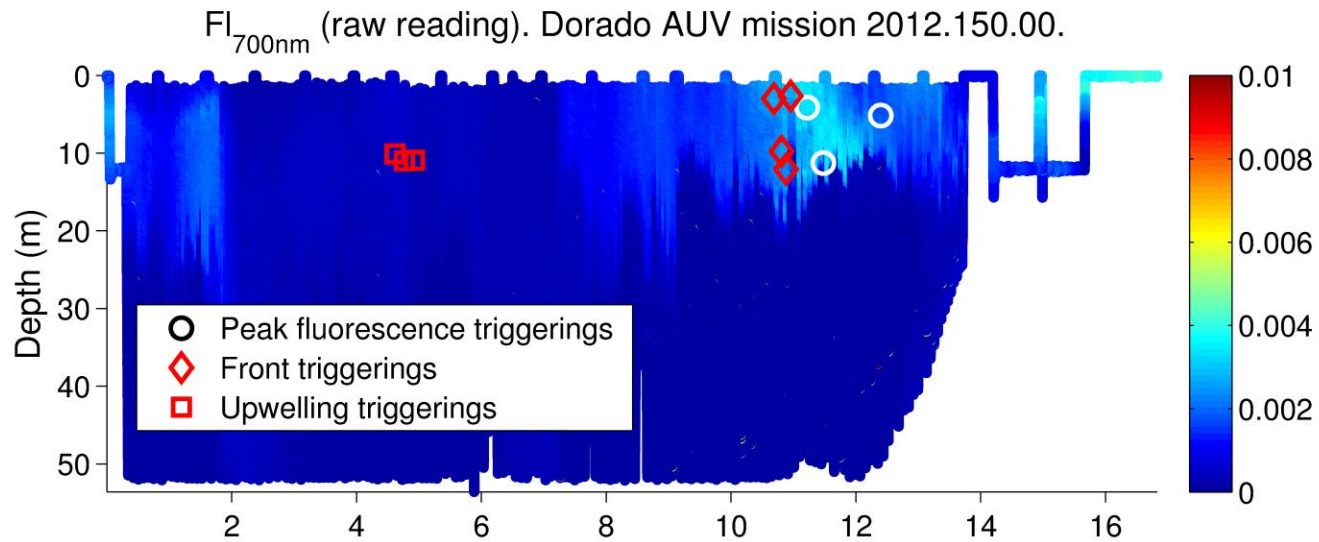
MBARI Dorado AUV



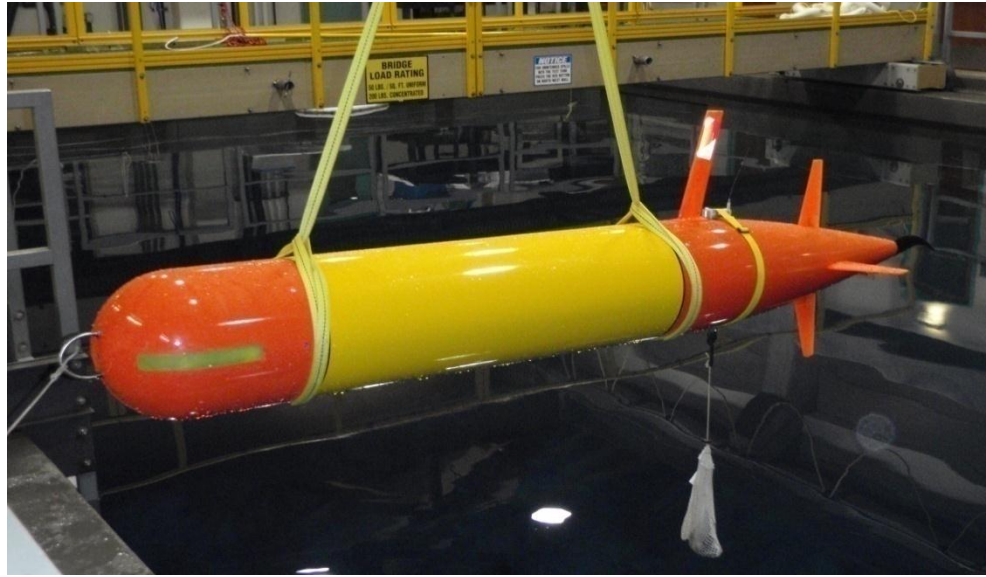
Photos courtesy of Larry Bird and Alana Sherman

Biological Analysis Results of the 10 Gulpers' Water Samples

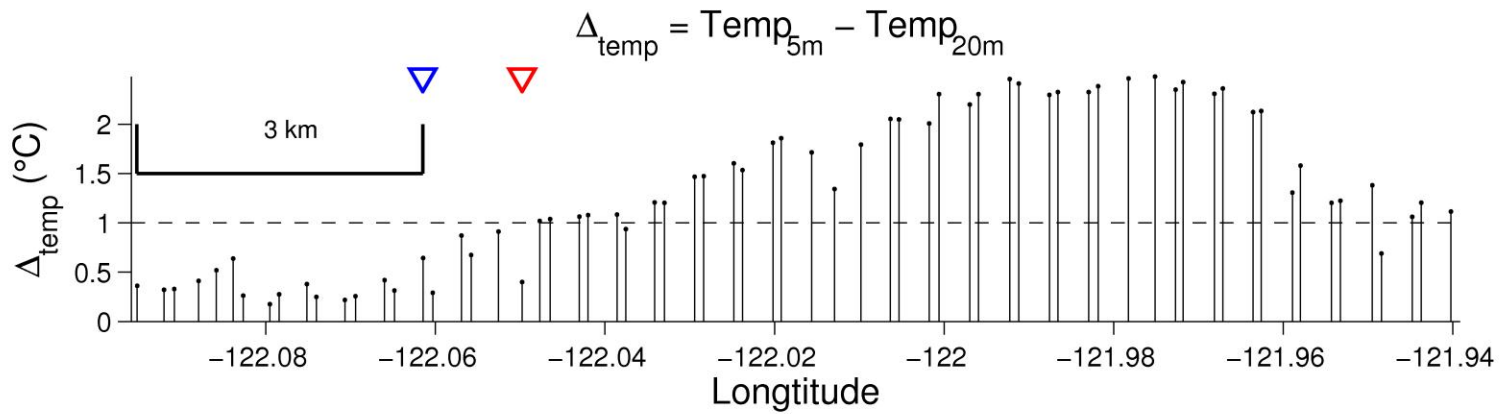
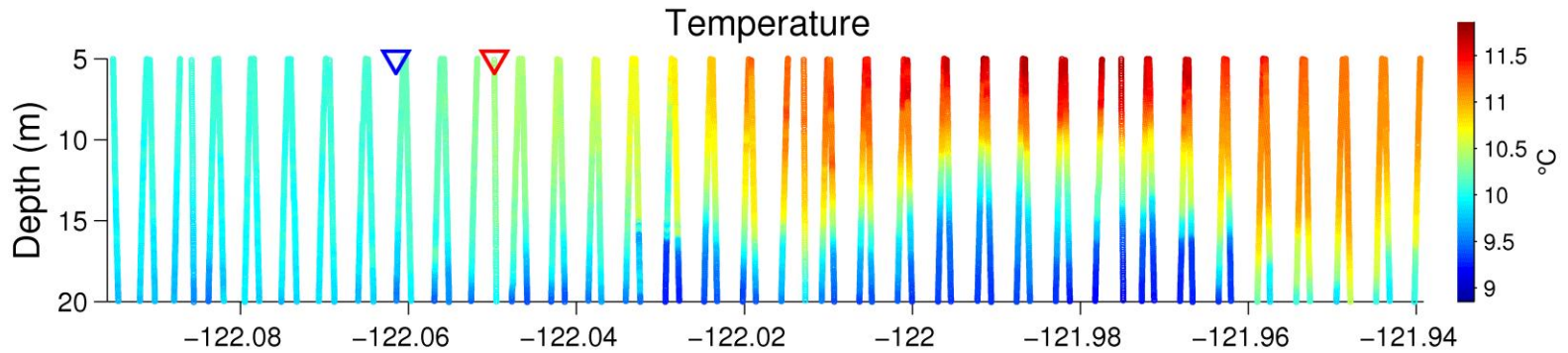
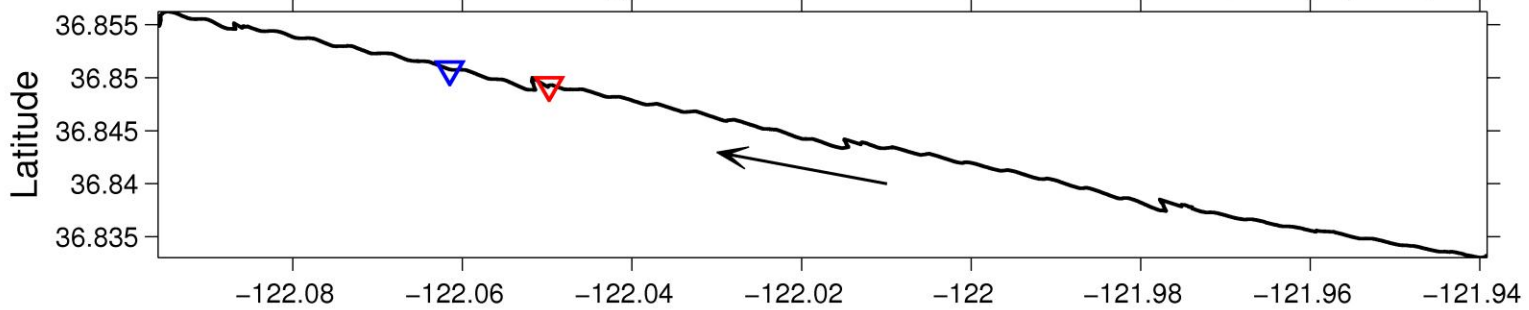


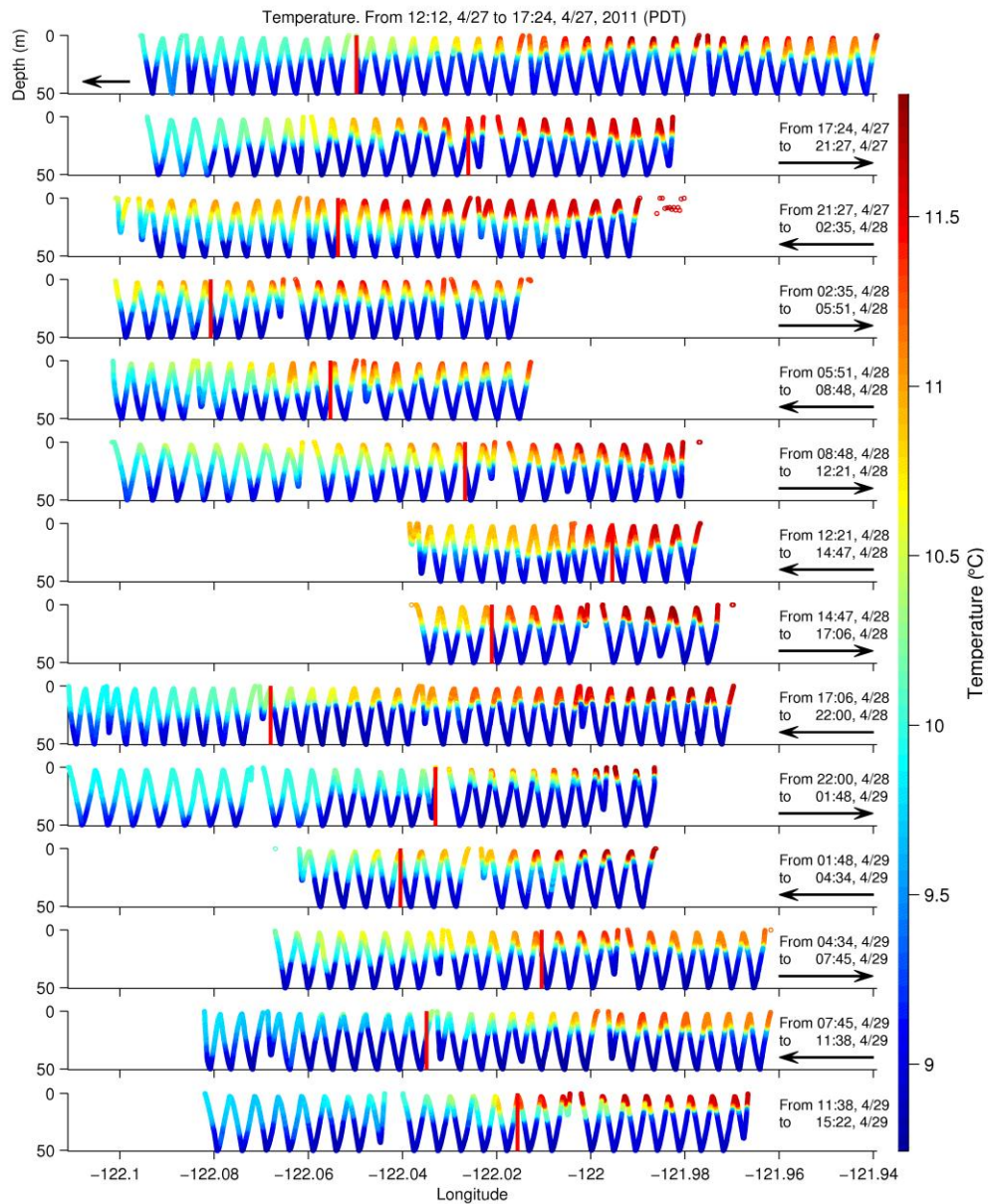


MBARI Tethys long-range AUV



AUV's 1st transect through the front. From 12:12 to 17:24, 4/27, 2011 (PDT)



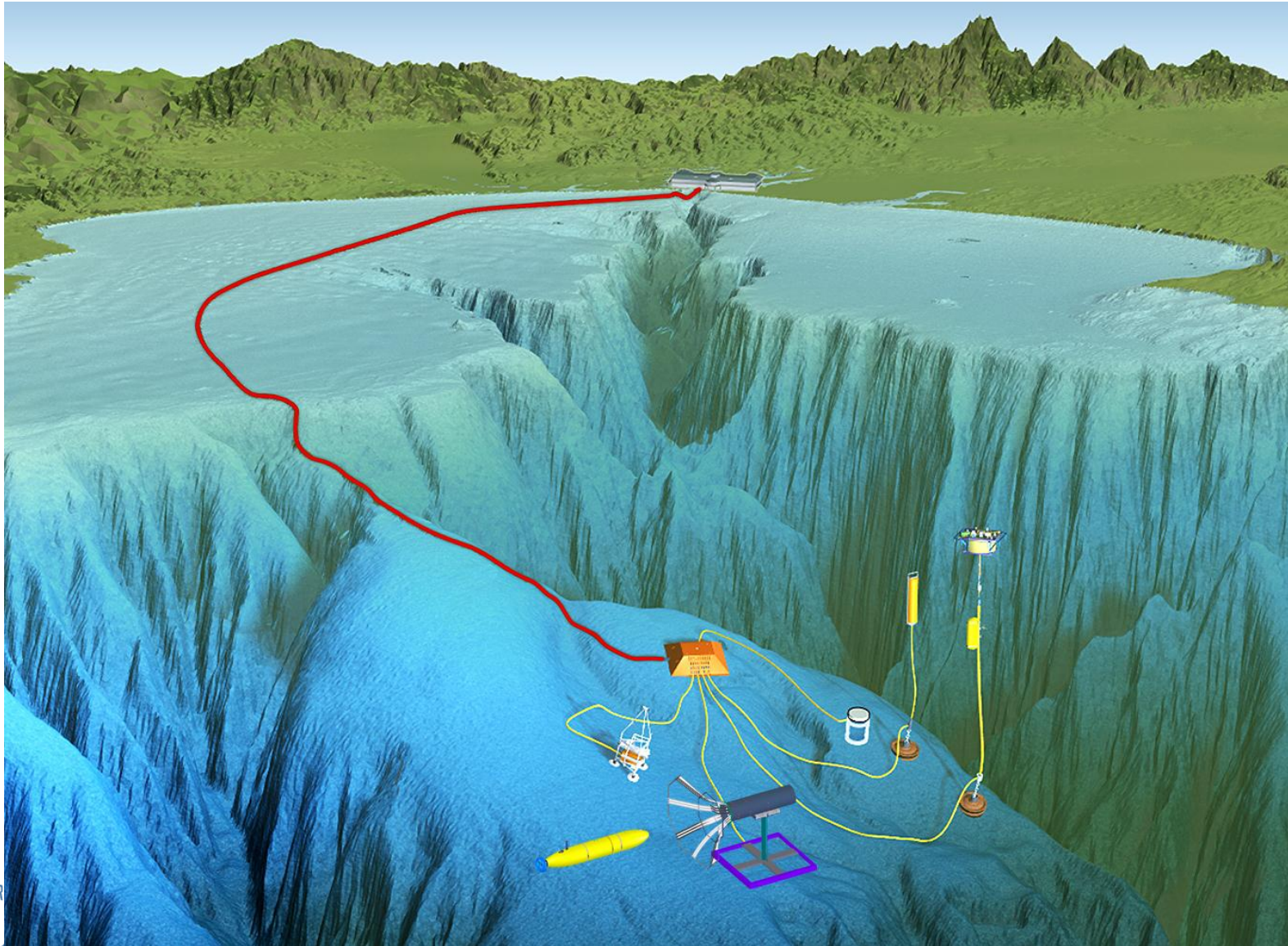




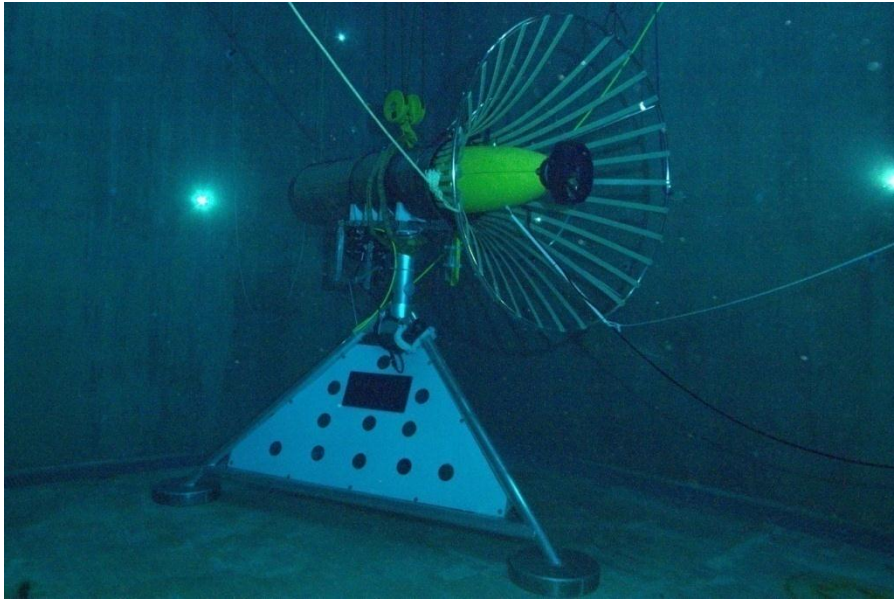
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 - 长处：大范围游动搜索。
 - 短处：无法对空间点不间断监测，知此时不知彼时。
- **两者协同，**
则长短互补，“攻”（游动搜索）“守”（长期监测）兼备。

Adaptive Ocean Observation: Cabled Observatory + AUVs



AUV Docking



- Autonomous homing and docking
- Batteries recharge
- Data download
- Mission upload
- Vehicle sleep/wakeup
- Code modification & recompile

Bellingham, Hobson, McEwen, and McBride

November 2012

Summary

- Fixed and mobile platforms have their respective merits and shortcomings. The two types of platforms play complementary roles in an ocean observing system.
- Design of adaptive observing methods for either type of platform is based on the targeted oceanographic feature.
- The efficacy of an ocean observing system will be greatly enhanced by the adaptive observing capabilities of the fixed and mobile components.



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