利用固定平台及自主水下航行器
实现自适应海洋观测


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Outline

• Review of adaptive signal processing
• Adaptive ocean observation
  o Moorings
  o 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 input; (b) reference input; (c) noise canceler output. From B. Widrow et al., *Adaptive Noise Cancelling: 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.

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。
  - 短处: 空间位置固定，知此处不知彼处。
An Adaptive Mooring – Submerged Autonomous Launch Platform

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

Autonomous Underwater Vehicles (AUVs) in Ocean Observation

1. Searching for hydrothermal vents

From [www.divediscover.whoi.edu/vents/basics.html](http://www.divediscover.whoi.edu/vents/basics.html) and [German et al., *Deep-Sea Research I*, 2008 2010]
WHOI ABE AUV’s 3-phase search for hydrothermal vents

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

- 固定平台
  - 长处：长时间、不间断监测。
  - 短处：空间位置固定，知此处不知彼处。

- 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

From [Leonard et al., Journal of Field Robotics, 2010]
3. Adaptive sampling and tracking of an upwelling front
Distinguishing between upwelling water and stratified water

Stratified water  Upwelling front  Upwelling water

Temperature

Chlorophyll fluorescence

Depth
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

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)

\[ \Delta_{\text{temp}} = \text{Temp}_{5m} - \text{Temp}_{20m} \]
固定平台
  - 长处：长时间、不间断监测。
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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
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.
Acknowledgments

• The David and Lucile Packard Foundation

• E. Chavez, R. Vrijenhoek, and C. Scholin for helpful discussions.

• H. Thomas, D. Thompson, and D. Conlin for Dorado AUV operations

• T. Hoover, B. Kieft, B. Hobson, and D. Klimov for Tethys AUV operations.