ANLY-601
Advanced Pattern Recognition

Spring 2018

L5b --- Example sequential test

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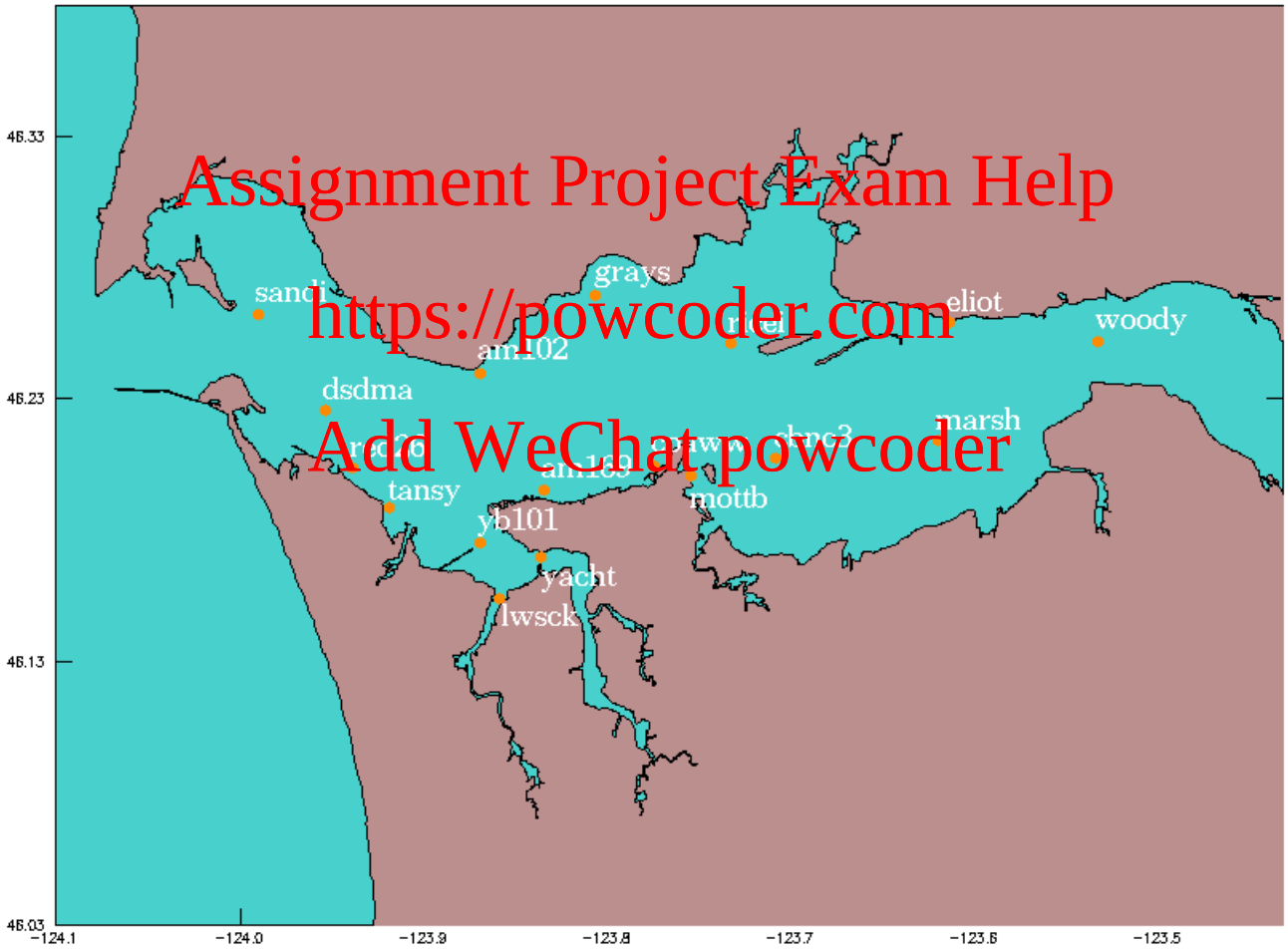
Detection of Marine Sensor Biofouling

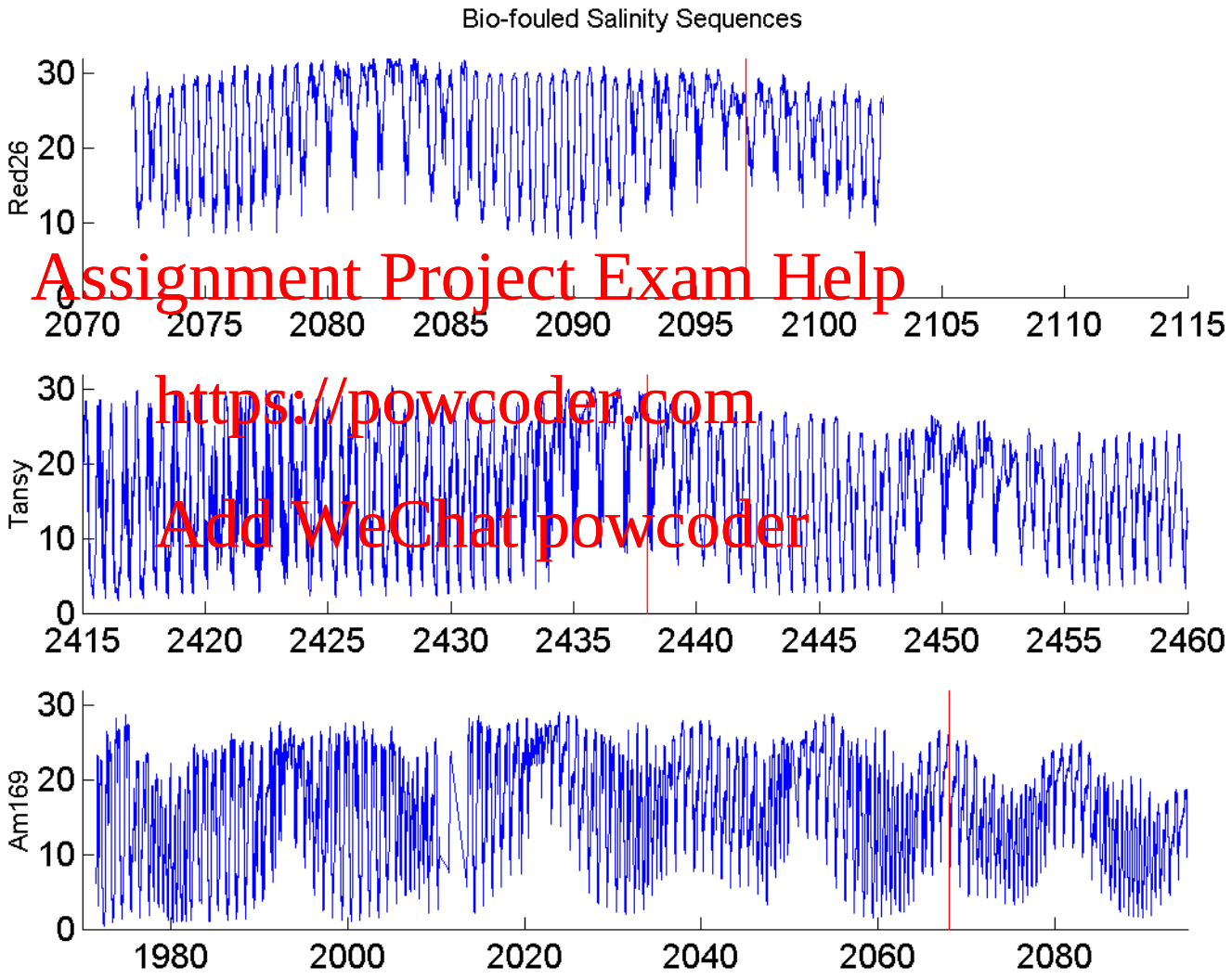


Conductivity Sensor Biofouling

CT1448, 9/28/01

CT1459, 9/30/02

CT1449, 8/28/01



Conductivity Sensor Biofouling

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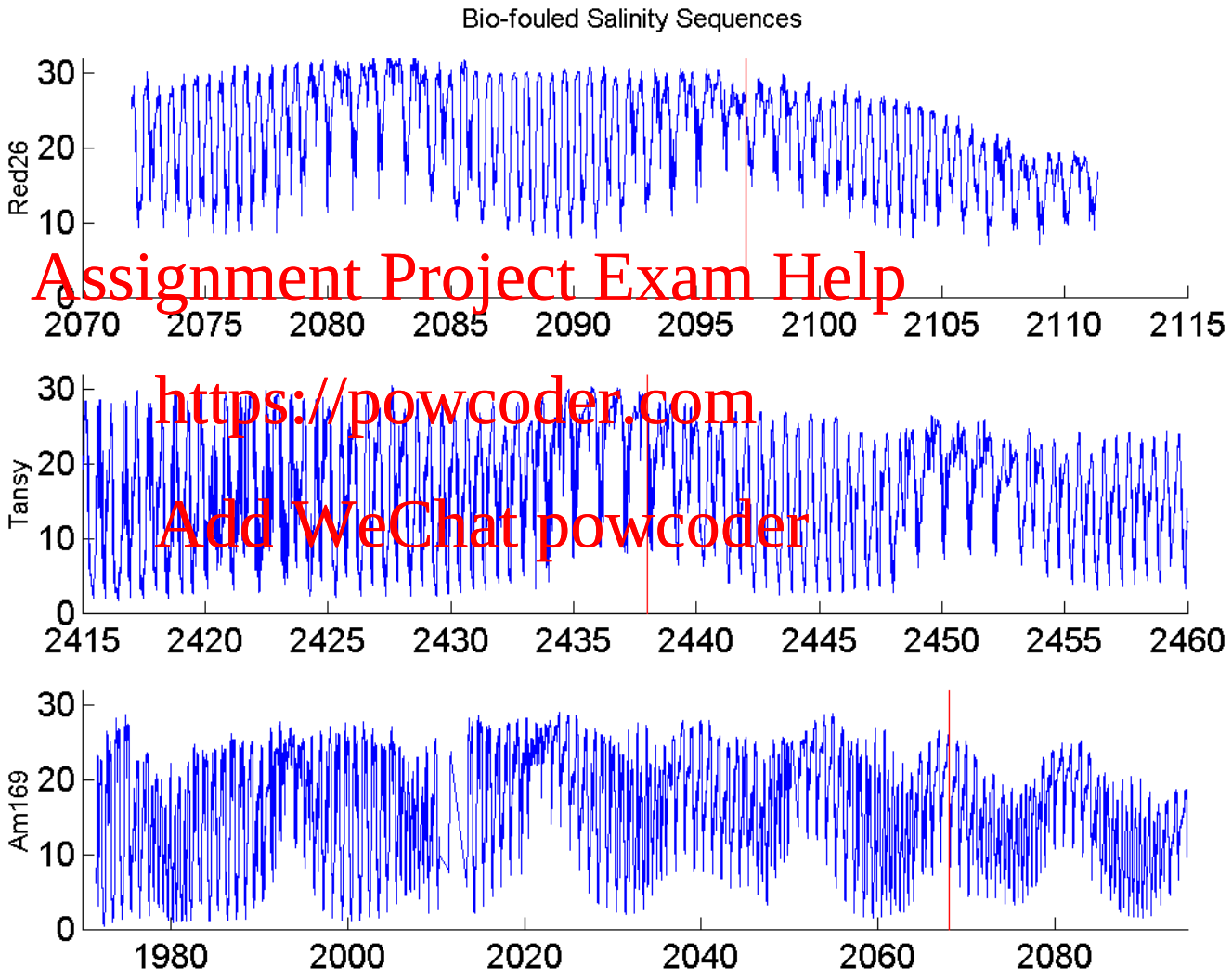


Biofouling Detection

- Detect onset of biofouling within several diurnal cycles
- Challenges
  - Variability of fouling signature
  - Very few examples of fouling onset (many days of lost conductivity data, but few episodes) – can't use clean/fouled discriminators.
  - Distinguish natural variation from sensor degradation

Detection Algorithm

Sequential likelihood ratio test

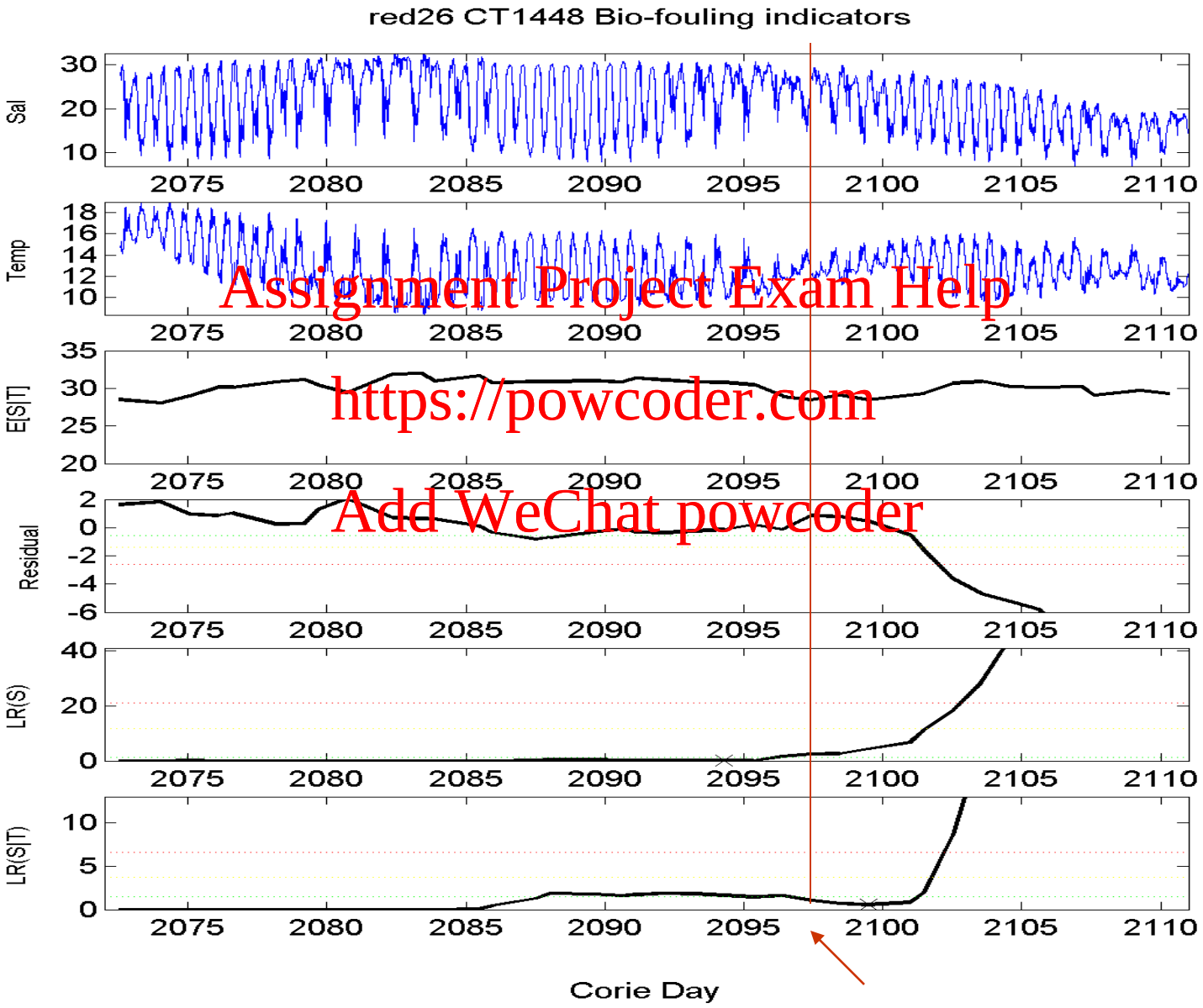
$$h(Now) = \sum_{n=Now-\tau}^{Now} \ln \frac{p(x_n \mid T_n, fouled)}{p(x_n \mid T_n, clean)} \begin{matrix} fouled \\ > \\ < \\ clean \end{matrix} \lambda$$

Now is current time
Now-τ is start of fouling event (unknown)
x_n is salinity at time *n*
T_n is vector of local water temperatures at time *n*
λ is detection threshold (set by specifying *false alarm rate*)

p(x|clean) is Gaussian with mean E[s|T] dependent on observed tidal variation of *local temperature* (i.e. predict salinity from temperature) and variance var(s|T)

p(x|fouled) is Gaussian with mean *decreasing linearly (slope m).*

Example of On-Line Detector Signals



Impact and Further Development

- Initial detectors placed on-line in spring of 2001.
- Detectors eventually placed at all observing sites.
- Data Preservation
  - Prior to the deployment (four years of data from 1997 through the summer of 2001), CORIE salinity sensors suffered a 68% data loss due to biofouling.
  - Post-deployment (spring/summer 2001 through February 2003), data loss due to bio-fouling dropped to 35%. This includes delays in responding to the event detection.
  - If all sensors were attended to immediately following a detected event, the data loss would have dropped to 17%.
  - DETECTORS CUT CORIE BIOFOULING-INDUCED DATA LOSS IN HALF

Impact and Further Development

- One false alarm due to precipitation; one unexplained false alarm.
- Seasonal changes in river/ocean temperature profile require different predictive models at different times of year.
  - We developed mixture models for prediction that automatically adjust to current temperature profile conditions in the river-estuary-ocean system.

References

Leen, T.K.; Archer, C; Baptista, A. Parameterized Novelty Detector for Environmental Sensor Monitoring. *Advances in Neural Information Processing Systems 16*, Thrun, Saul, and Scholkopf (eds.), The Mit Press, 2004.

Archer, C; Baptista, A; Leen, T.K. "Fault detection for salinity sensors in the Columbia River Estuary. *Water Resources Research,* **39**, 1060, 2003.

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