Challenges for long-term CTD deployments at active hot vents and cold seeps - Examples from Ocean Networks Canada NEPTUNE observatory and OOI Regional Cabled Array

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Introduction

Networked CTD instruments can be configured to resolve various spatial and temporal scales of oceanographic processes. Stationary, long-term, installations can produce time series of *Essential Ocean Variables* (EOV)s, as defined by the Global Ocean Observing System (GOOS). However, the costs involved in maintaining observational infrastructure are high and put constraints on the frequency it can be maintained. For certain locations CTD deployment times may exceed the apparent sensor stability. This seems to be especially true in methane-rich environments.

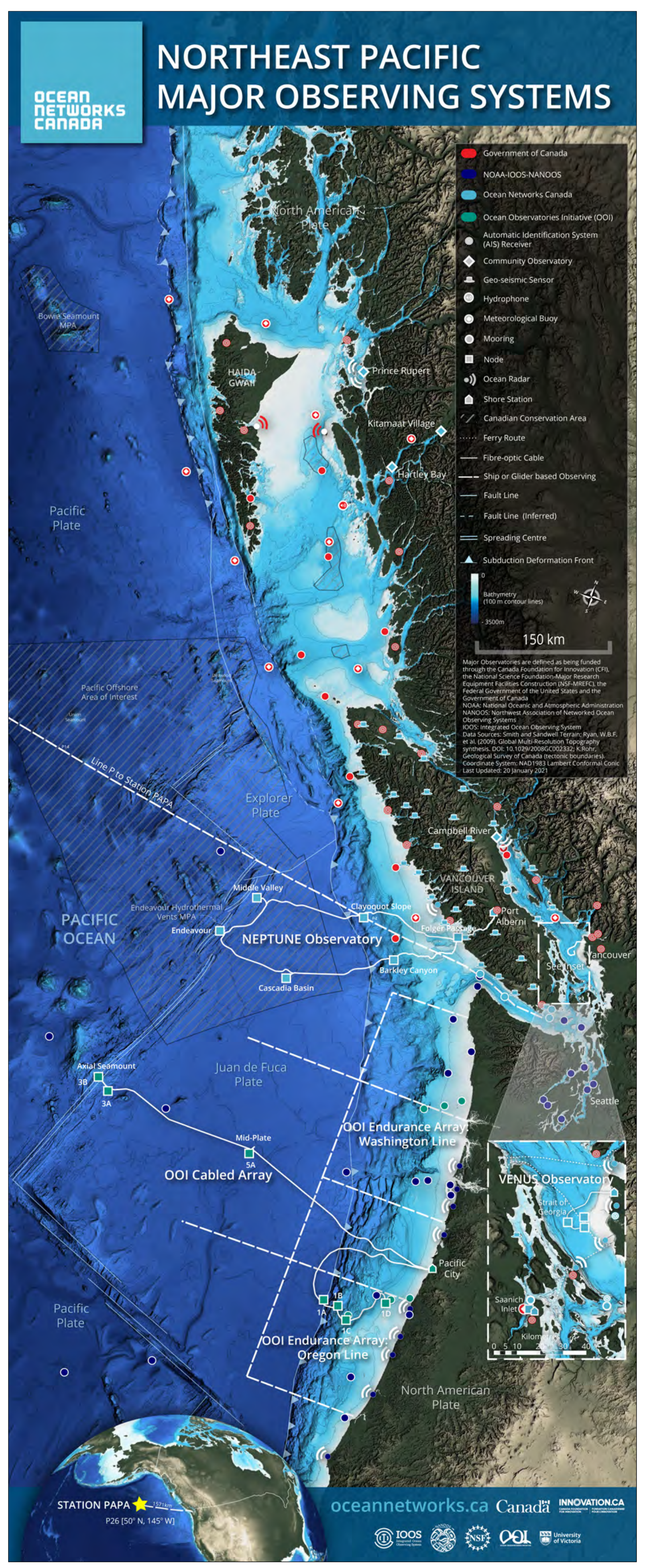

Figure 1. ONC North-East Pacific Undersea Networked Experiments (NEPTUNE) and OOI Regional Cabled Array (RCA).

Site A: Bullseye Vent

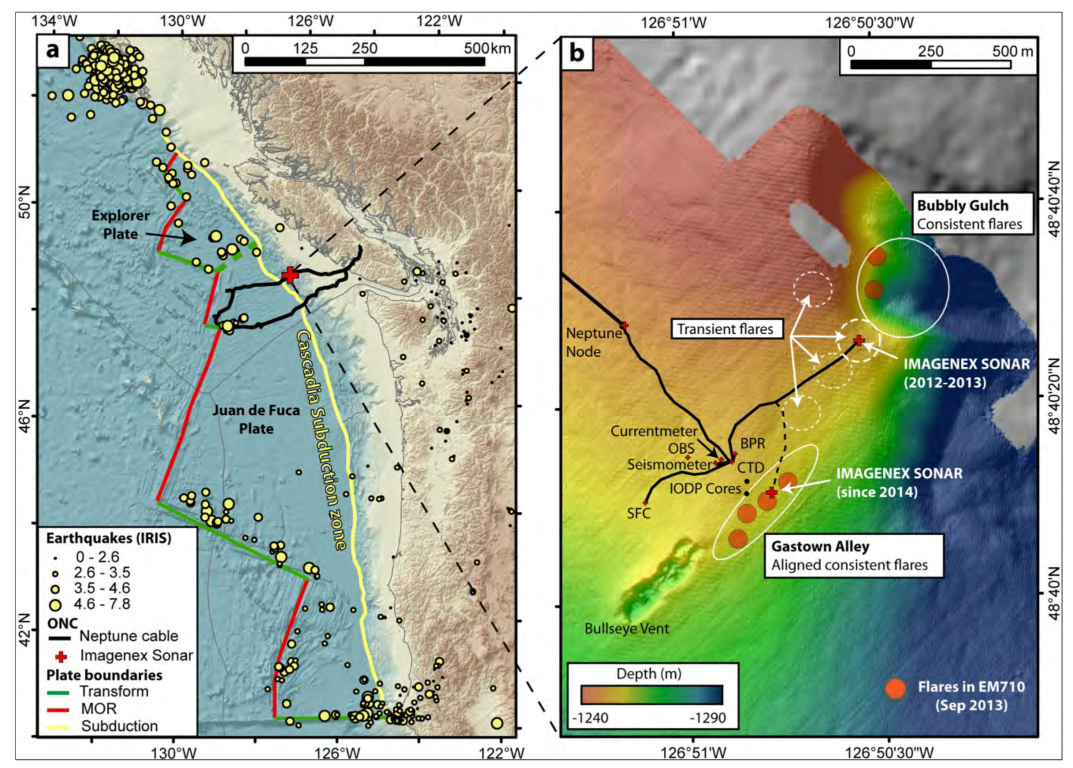

Figure 2. CTD location at Bullseye Vent, installed in 2011 and relocated in 2016. The Bullseye Vent (Depth $1250m$) is part of a larger cold vent field on the mid-slope of the northern Cascadia margin. The vent sizes vary between a few to several hundreds of meters in diameter. (Römer et al., 2016).

Site B: Southern Hydrate Ridge

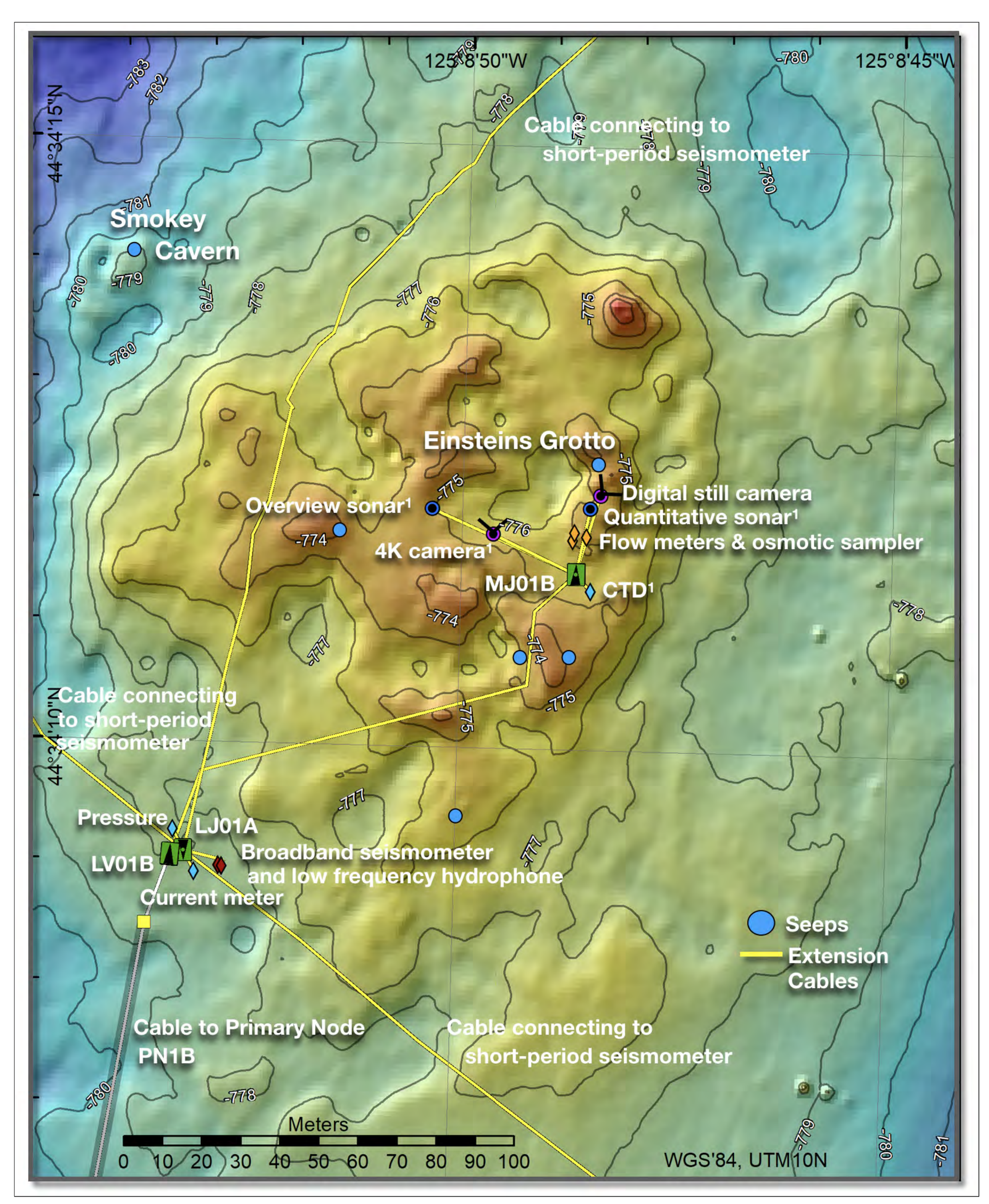

Figure 3. CTD location at Southern Hydrate Ridge as installed in 2019. Southern Hydrate Ridge (Depth $780m$) is a site of methane seeps located in the central Cascadia margin. At Southern Hydrate Ridge gas-rich hydrate deposits can be found. (MARUM, University of Washington, 2022).

Conductivity Data

Methods:

Each time series was generated starting from raw conductivity data, meaning no automated quality control and assurance (QAQC) tests were applied yet. For plotting, data points outside three standard deviations (3σ) of the mean were treated as outliers and excluded.

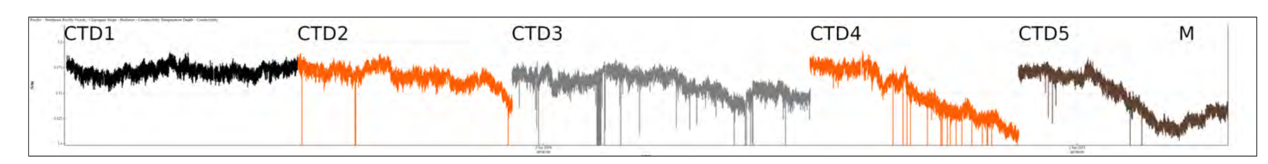

Figure 4. Times series of conductivity $[S/m]$ collected at Bullseye Vent by 5 CTDs [CTD 1-5; see Table 1). The apparent sensor drift can be visually estimated from the misalignment between consecutive deployments. **Interestingly**, when the configuration of CTD5 (profiling mode) was changed to CTD5M (moored mode), some of the conductivity sensor drift reversed.

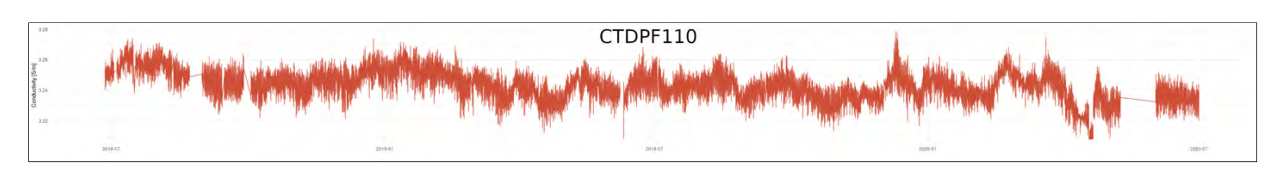

Figure 5. Time series of conductivity $[S/m]$ collected at Southern Hydrate Ridge [CTDPFA110; see Table 1). The instrument was maintained and redeployed in summer 2020. MARUM, 2022.

Configurations

CTD	Model	Mode	SR	Configuration
CTD1	SBE 37-SI/SIP	NA	60s	NA
CTD2	SBE 16plus V2	Moored	60s	NAV=1, Flush=40s
CTD3	SBE 19plus V2	Profiling	0.25s	NAV=1, Delay=60s
CTD4	SBE 19plus V2	Profiling	1s	NAV=4, Delay=60s
CTD5	SBE 19plus V2	Profiling	1s	NAV=4, Delay=60s
CTDPFA110	SBE 16plus V2	Moored	60s	NAV=20, Flush=40s
CTD5M	SBE 19plus V2	Moored	840s	NCIycles=80,Delay=40s

Table 1. CTD models and their configurations used in the collection of data shown in Figure 3 and 4. CTD1 was deployed inside a casing/ box. CTD4 and CTDD5 were positioned on a tripod monument, roughly $2mab$. CTD5M is the same networked instrument as CTD5 and was reconfigured into "moored" mode Dec. 15th, 2021 remotely.

Findings

As seen in ROV camera footage and post-recovery inspections (see Figure 6), CTD instruments at Bullseye Vent show signs of external and internal bio-fouling. Comparisons between conductivity and temperature ratios in C/T diagrams (Figure 7) are investigated to better understand the sensor drift characteristics.

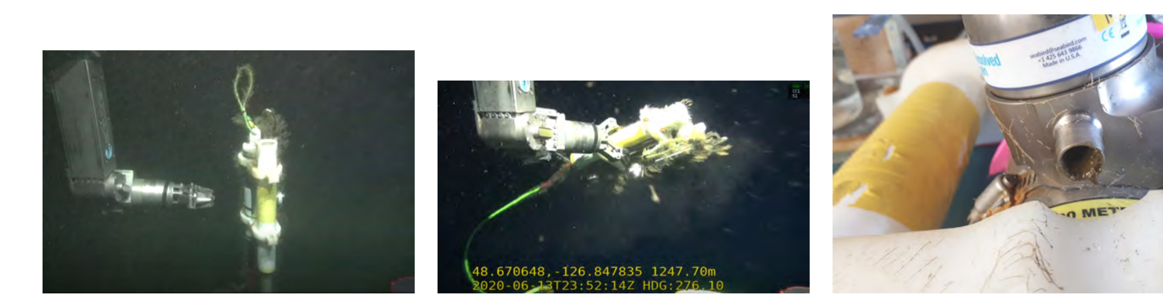

Figure 6. CTD coming into ROV view (left). Bio-fouling on CTD housing and dispersed into the water (middle). Organic material inside C/T duct and upstream oxygen sensor intake (right).

C/T diagrams:

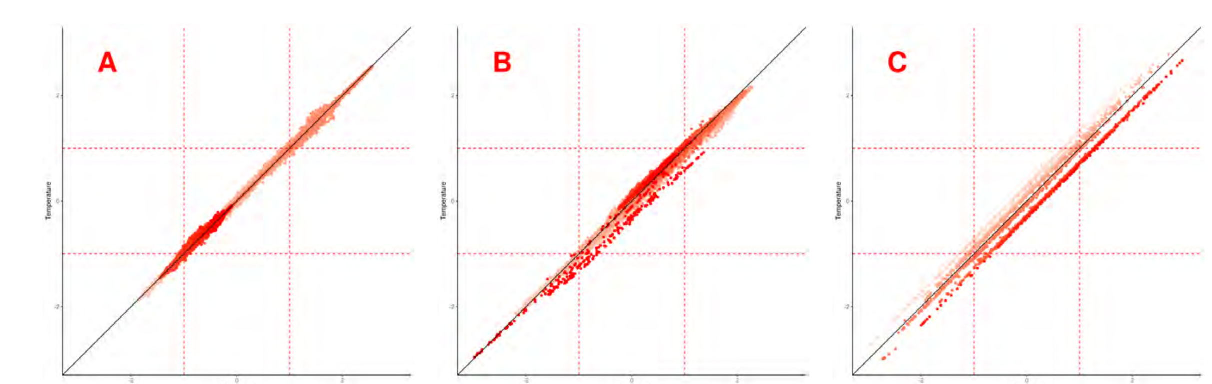

Figure 7. C/T diagrams showing ratios of normalized ($\mathcal{N}$) conductivity and temperature at i) the beginning of a deployment (A), ii) mid-deployment (B) and iii) at the end of a deployment, after switching into "moored" mode (C) for a CTD deployed at Bullseye Vent (CTD5(M); see Table 1). Light red colors correspond to the beginning of sample data, colors darken as time progresses.

Discussion

Currently, main **points of discussion** are:

- **Sample rate**; What is the 'optimal' trade-off between high-resolution sampling and longevity of deployments?
- **Bio-Fouling**; Are microbes methanotrophic?
- **TBT**; Are there other option than Tributyltin (TBT)?
- **Methane hydrates**; What are physical and biogenic factors detrimental to conductivity sensor stability?

References

Römer, M., Riedel, M., Scherwath, M., Heesemann, M. and Spence, G.D., 2016. Tidally controlled gas bubble emissions: A comprehensive study using long-term monitoring data from the NEPTUNE cabled observatory offshore Vancouver Island. Geochemistry, Geophysics, Geosystems, 17(9), pp.3797-3814.