Gas hydrate observatories: Long-term observations from gas hydrate systems on the Cascadia Margin

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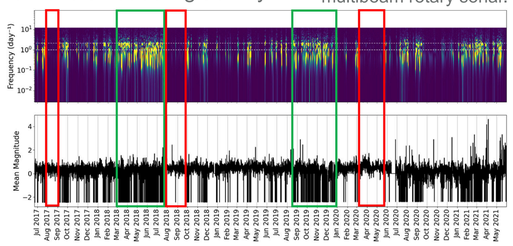
Introduction:

Both Ocean Networks Canada (ONC) and the Ocean Observatories Initiative (OOI) cover gas hydrate location with 24/7 high-resolution monitoring.
Gas hydrate systems are very dynamic, and single snapshots of observations (e.g. during research cruises) can miss rare events, do not see the full range of variation, and may not reveal the triggers of any changes in the system.
Long-term monitoring facilitate research to understand the complete gas hydrate system, and cabled observatories expand the range of instrumentation by providing permanent power and archiving large amounts of data in near-real time.

Clayoquot Slope

Active gas hydrate seep site at 1250 m water depth. As an example, 10 years of sonar data show variations in bubble activity. Tides drive much of the variations but cannot explain the timing of weeks- to months-long periods of high or low overall bubbling activity.

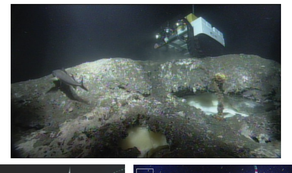
Above: Cabled Imagenex 270 kHz multibeam rotary sonar.

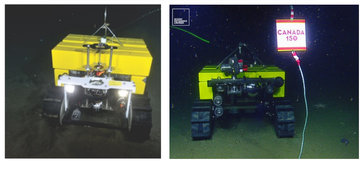


Above: Bubble activity in sonar backscatter, with red boxes indicating constant venting and green boxes indicating weak, intermittent venting. Upper panel shows frequency spectrum with white dashed lines at tidal periods. Bottom panel shows dimensionless backscatter intensity. (Marcon et al., 2022)

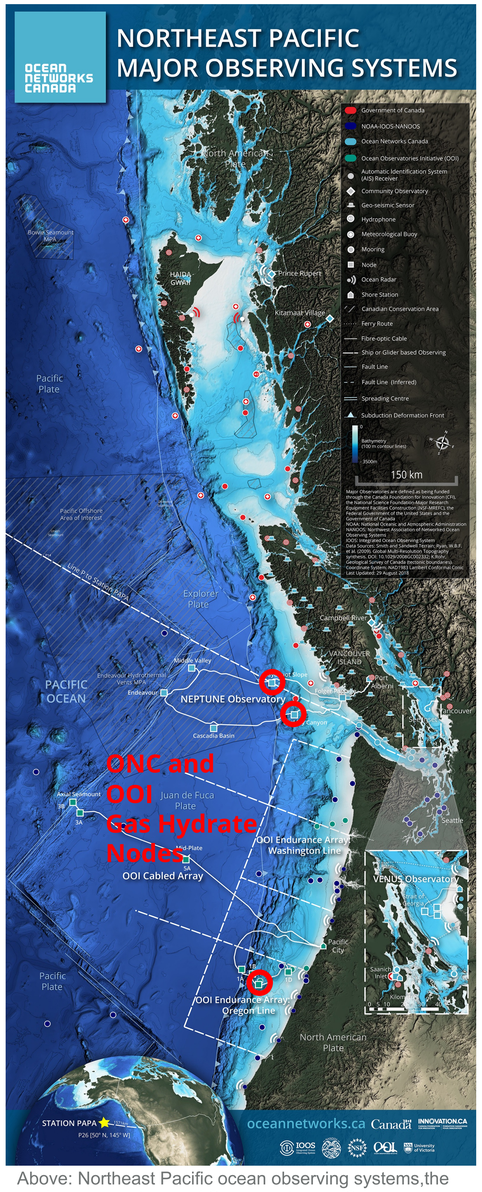
Barkley Canyon

Gas hydrate site at 890 m depth with hydrate mounds, exposed hydrate, and thermogenic methane. As an example, Wally the world's first Internet Operated Vehicle (IOV) is driven around hydrate mounds and monitors environmental and benthic activity.

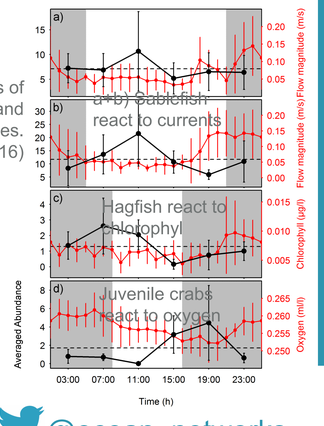




Left: Various iterations of Wally the crawler have been operating in Barkley Canyon since 2009. Correlating visual observations with environmental data allows to determine species' favourable conditions.



Above: Northeast Pacific ocean observing systems,the cabled observatories of Ocean Networks Canada (ONC) and the Ocean Observatories Initiative (OOI).

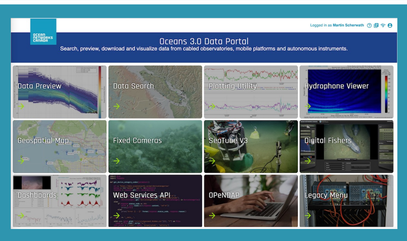


Right: Statistical analysis of species abundance and environmental changes. (Chatzievangelou et al., 2016)

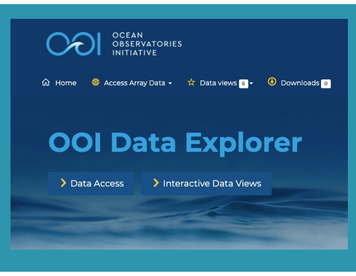
Long-term monitoring is **key** to detect the **full scale** of variations of a dynamic gas hydrate system – and *you* can **investigate**!

All data are **free** and **open access**:

- *https://data.oceannetworks.ca*

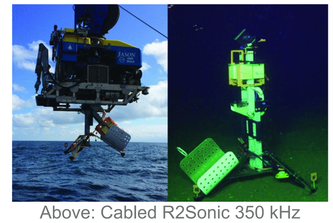


- *https://dataexplorer.oceanobservatories.org/*

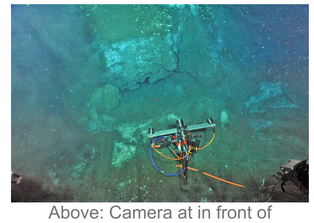


Southern Hydrate Ridge

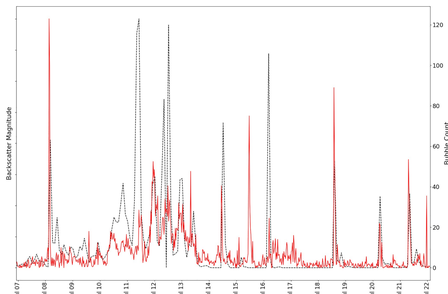
Active gas hydrate seep site at 1240 m water depth. As an example, the so-called Southern Hydrate Ridge Overview Sonar (SHROS) was installed in 2018 to constantly measure methane bubble flux, together with a co-located camera seeing bubbles from Einstein's Grotto.



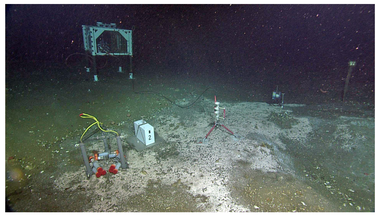
Above: Cabled R2Sonic 350 kHz multibeam rotary sonar, during deployment with the ROV Jason. (Marcon et al., 2019)



Above: Camera at in front of Einstein's Grotto, imaging individual bubbles escaping the vent which is in view of the bubble sonar.



Left: Variations in methane bubbling recorded with sonar (black) and camera (red) from Einstein's Grotto area. Note the sonar has a larger footprint and has spikes where the camera doesn't. On the other hand, spikes in the camera data come from a more frequent sampling period (30 min for the camera compared to every 2 h for the sonar).



Right: Other instrumentation at the hydrate sites (here from Southern Hydrate Ridge, with bacterial matts on the seafloor) also produce long-term time series ready for analysis and discoveries.

Hydrate Observing Systems at ONC and OOI

Location (depth)	Installation	Description
Barkley Canyon (890 m) Hydrate Mounds	Seafloor Crawler Wally	Camera, CTD, current meter, methane sensor, fluorometer, turbidity meter
	Two 675 kHz imaging rotary sonars	100 m radius; for hydrate mounds, potential gas flares, tracking Wally.
	Environmental sensors	Temperature, salinity, pressure, oxygen and currents.
Clayoquot Slope (1250 m) Active gas venting	ACORK U1364A	300 m deep below seafloor, with temperature, pressure, bottom seismometer and tiltmeter; connected since June 2017.
	SCIMPI U1416A	240 m deep below seafloor, with temperature, pressure and resistivity; running autonomously with regular data downloads.
	260 kHz multi-beam sonar	100 m radius; for gas bubbles
	Broadband seismometer	With a differential pressure gauge, potential for seafloor compliance
	Tiltmeter	For seafloor deformation and ground shaking
	CSEM	Partially working; was discontinued in 2013.
	Environmental sensors	Temperature, salinity, pressure, oxygen and currents (incl. ADCP with backscatter from bubbles).
Hydrate Ridge (1242 m) Hydrate Mounds and Active gas venting	Seep sensors	Camera, sonar (200 m radius), flowmeter, OSMO fluid sampler, mass spectrometer
	Seismometers	Array of a broadband and several short-period seismometers for localizing local seismicity
	Environmental sensors	Temperature, salinity, pressure, oxygen and currents (incl. ADCP with backscatter from bubbles).

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