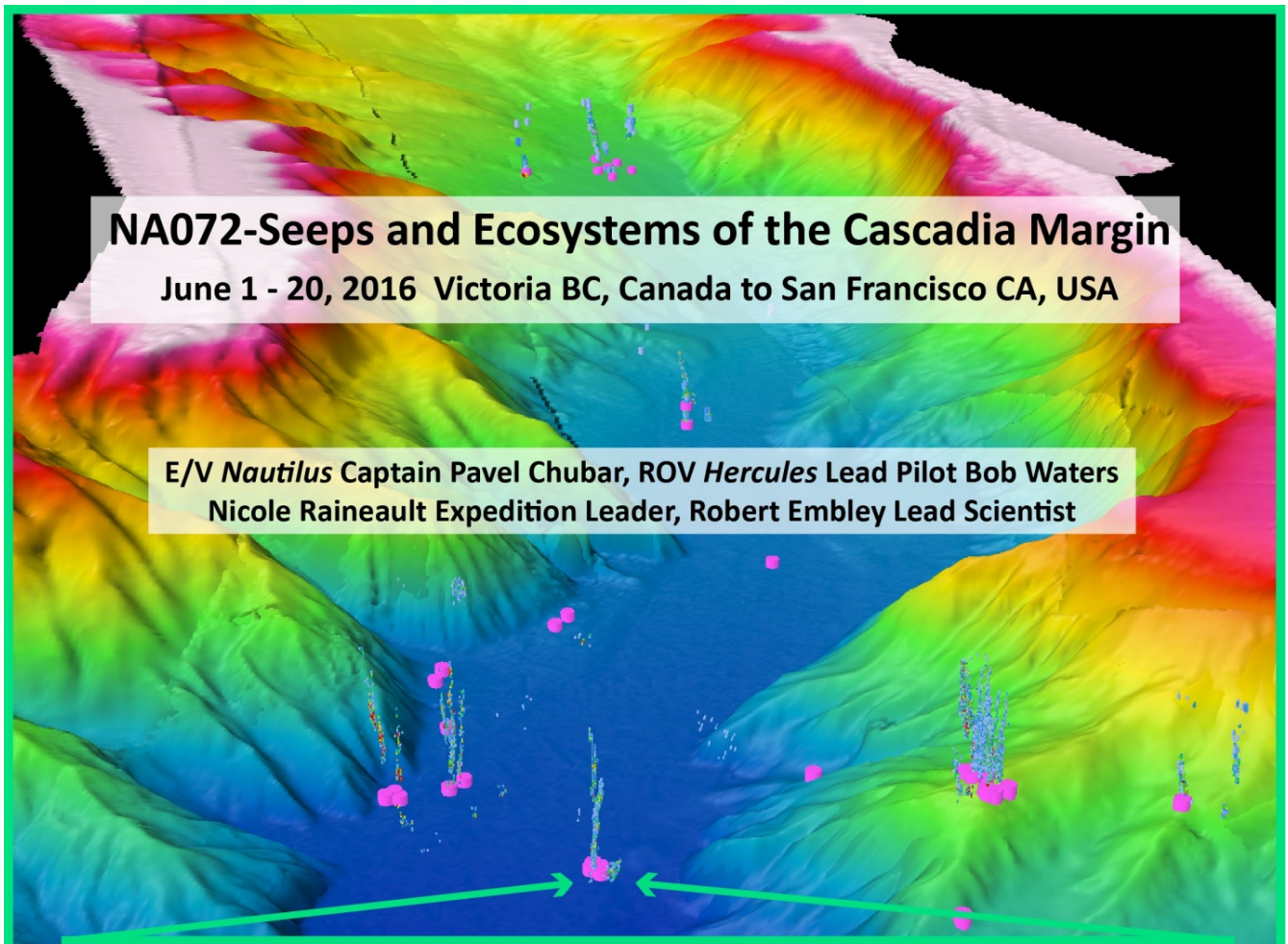
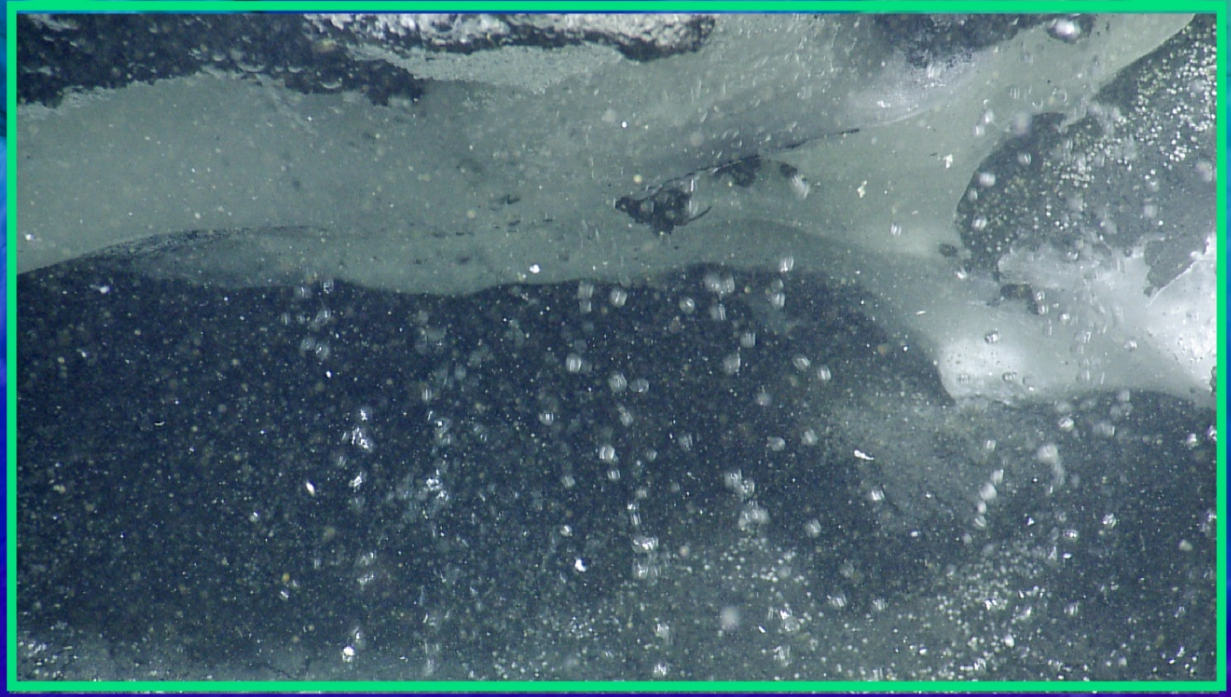
NA072-Seeps and Ecosystems of the Cascadia Margin

June 1 - 20, 2016 Victoria BC, Canada to San Francisco CA, USA



E/V *Nautilus* Captain Pavel Chubar, ROV *Hercules* Lead Pilot Bob Waters
Nicole Raineault Expedition Leader, Robert Embley Lead Scientist



Report compiled by Susan Merle (CIMRS OSU/NOAA) and Robert Embley (NOAA/PMEL)

Cover: Seafloor image (~0.5 m across) of a methane hydrate shelf above bubble streams discovered on dive H1517 at Astoria Canyon on the southern canyon floor, 850 m depth. 3d background image of Astoria canyon bathymetry is overlaid with methane bubble streams discovered on NA072 (magenta cylinders). Bubble streams with high intensity values are also imaged as 3d point clusters. 3d image is ~8 km across mid-image and 3 times vertically exaggerated. (Created by Susan G. Merle)

E/V *Nautilus* and ROV *Hercules* are owned and operated by the Ocean Exploration Trust Inc. (OET). The expedition was collaborative between OET and the NOAA Ocean Exploration and Research Program.

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An Overview of E/V Nautilus Cruise NA072
"Seeps and Ecosystems of the Cascadia Margin"

Bob Embley NOAA/PMEL

The NA072 (E/V *Nautilus*) cruise began in Victoria on June 1 and ended in San Francisco on June 20 (Fig. 1, Table 1). The cruise included: 1) surveys and dives that characterized a WWII shipwreck, *Coast Trader (Dive H1511*), 2) habitat characterization within the outer continental shelf within the Olympic Coast National Marine Sanctuary (Dive H1514), 3) a dive and survey to characterize seafloor habitat at Gray's sponge reef near Grays Canyon, Washington (Dive H1516), 4) characterization of Bamboo coral habitat on the continental slope off southern Oregon/northern California (Dive H1523), and 5) extensive surveys and sampling of methane seeps along the entire U. S. Cascadia continental margin (from Strait of Juan de Fuca to Cape Mendocino – Dives H1510, H1513, H1517-H1521, H1523, H1524).

Cruise NA072 involved collaborations (ashore and at sea) with the (NOAA) Pacific Marine Environmental Laboratory (see Tables 2 and 3), (NOAA) Office of National Marine Sanctuaries (Jim Delgado and Mike Brennan), (NOAA) Olympic Coast National Marine Sanctuary (Liam Antrim), (NOAA) Northwest Fisheries Science Center (Elizabeth Clarke and Curt Whitmire), (NOAA) Southwest Fisheries Science Center (Mary Yoklavich), University of Washington (Paul Johnson and Evan Solomon) and Oregon State University (see lists on Tables 2 and 3). Nicole Raineault (OET) served as expedition leader, and Steve Hammond (ashore) and Bob Embley (at sea) were lead scientists.

The exploration carried out during NA072 resulted in the discovery of 450 methane bubble streams[1] in water depths ranging from 125 to 1625 m depth and characterized ten of these new seeps using the *Hercules* remotely operated vehicle (ROV). Two new sites of methane hydrate exposure were discovered on the seafloor; until now there were only three known sites of hydrate exposure on the Cascadia margin, two of which were discovered more than 20 years ago. Interestingly, we characterized a new type of topography on the southern Cascadia margin, carbonate reefs that were likely formed entirely by methane oxidation. The NA072 cruise greatly exceeded our expectations and the results clearly indicate that there are many more methane sources to be discovered on the Cascadia margin. Prior to NA072 there were very little data about methane flux in the southern area, between Heceta Bank (~43.7° N) and the northern Eel River basin (~41.7° N), but more than 120 bubble plumes were discovered in this region on NA072 within about a week of exploration. These results from NA072 provide insights relevant to NOAA goals, including climate adaptation/mitigation (methane being a

[1]Defined as vertically oriented sonar return originating at the seafloor

powerful greenhouse gas), ocean acidification, and healthy oceans (relationships between chemosynthetic ecosystems and fisheries).

During the first part of the cruise we were able to make ROV dives at previously identified by bubble plumes (but not characterized by ROV) as well as new targets identified by the *Nautilus*' sonar (like the floor of Astoria canyon where we discovered a methane hydrate exposure). As we proceeded south, we discovered many more new methane bubble streams. The ability to take advantage of these new discoveries depended on rapid analyses of the water column sonar data, which we were able to do on board. Subsequent dives with the *Hercules* ROV at selected sites often began within several hours following their discovery. The combination of the ship's multibeam system and the *Hercules* ROV (which was very flexible in its launch and recovery schedule) enabled us to enjoy a great mix of exploration in the pursuit of both discovery and science. Numerous new and interesting sites were also discovered that we didn't have time to characterize. These provide some prime targets for future exploration along the Cascadia margin.

Preliminary Results and Observations

The new seep sites were located within several geologic settings, including: (i) the continental shelf; (ii) canyons, including shallow heads, shoulders, and deep wall sites; (iii) accretionary ridges (where the sediments are being squeezed and faulted during the convergence between the Juan de Fuca and North American tectonic plates); and (iv) upper continental slopes in the ~500-600 m depth range. The *Hercules* ROV is an excellent platform for characterizing these new sites. We took 128 samples, including hard substrata, Niskin-bottle water samples, samples of methane acquired with gas-tight bottles (supplied by John Lupton's lab), suction samples of biology, corals, and push-core samples. At least one graduate student (S. Seabrook) got a substantial portion of her thesis material from this expedition.

The discovery and sampling of two new sites of methane hydrate exposures at 850 m and 1230 m depth provide new opportunities for understanding how hydrate disassociation occurs. The in-progress on-shore characterization of the bubbles sampled with gas-tight bottles will provide information about the source of the methane forming the bubbles. Noble gas analysis may shed light on the climate-relevant question by revealing whether the methane bubbles were released from hydrate or from a gaseous reservoir. Analysis of the samples collected over a large depth range at Astoria Canyon (at 850 m) adjacent to a hydrate outcrop and at 500 m will provide new data regarding this question. Other critical bubble samples were collected at the Heceta South Fault at 1230 m next to a hydrate site and at the SW Coquille Bank at a depth of about 600 m to expand the depth range of the bubble sample collection.

The methane dissociation process, which can be studied directly from the hydrate sites, is particularly important for addressing societally-relevant climate and other issues. A warming ocean could begin to destabilize methane hydrate at its upper limit of stability (~500 m on the Cascadia margin). A 2015 publication hypothesized that this man-made destabilization has already begun. Large-scale destabilization could potentially release methane, a powerful greenhouse gas, into the atmosphere. Such destabilization could also lead to tsunamagenic events from slope destabilization. Additional related potential hazards could result from developing methane hydrate as a fossil fuel resource. Time-series observations could determine if changes are occurring with time at methane seep sites on the Cascadia margin.

Characterization of the chemosynthetic ecosystems feeding on the methane was also an important cruise goal. In particular, how do these "seep" systems interact with the surrounding non-seep communities? The latter is of particular interest along the Cascadia margin, an area of economically valuable fisheries. As noted above, the seeps occur at all depths and various geological settings, but we have only characterized a small percentage of them.

Ultimately it will be important to develop techniques for monitoring ocean methane flux, particularly from dynamic plate boundaries such the Cascadia margin. In what may be an important experiment by the PMEL acoustics program, deployments of a small hydrophone at two vigorous bubble plume sites recorded detectible acoustic signatures during dives H1520 at Heceta SW and H1521 at Coquille SW. It may therefore be possible to use such acoustic data to obtain an estimate of the volume of methane being produced at an instrumented site. The *Hercules* ROV and the E/V *Nautilus* create a lot of acoustic noise and a logical next step would be to deploy a hydrophone at an active seep site and leave it there while the ship works elsewhere during a given expedition.

Time constraints allowed only minimal exploration and characterization of the large number of new methane seep sites found on NA072. Further exploration is critical for expanding the data base on methane seeps along the Cascadia margin and for conducting additional *in situ* characterization of sites encompassing a larger range of variables. We are confident that this will result in abundant value-added new results. We look forward to exploring what opportunities might exist for building on these exciting exploration and research results.

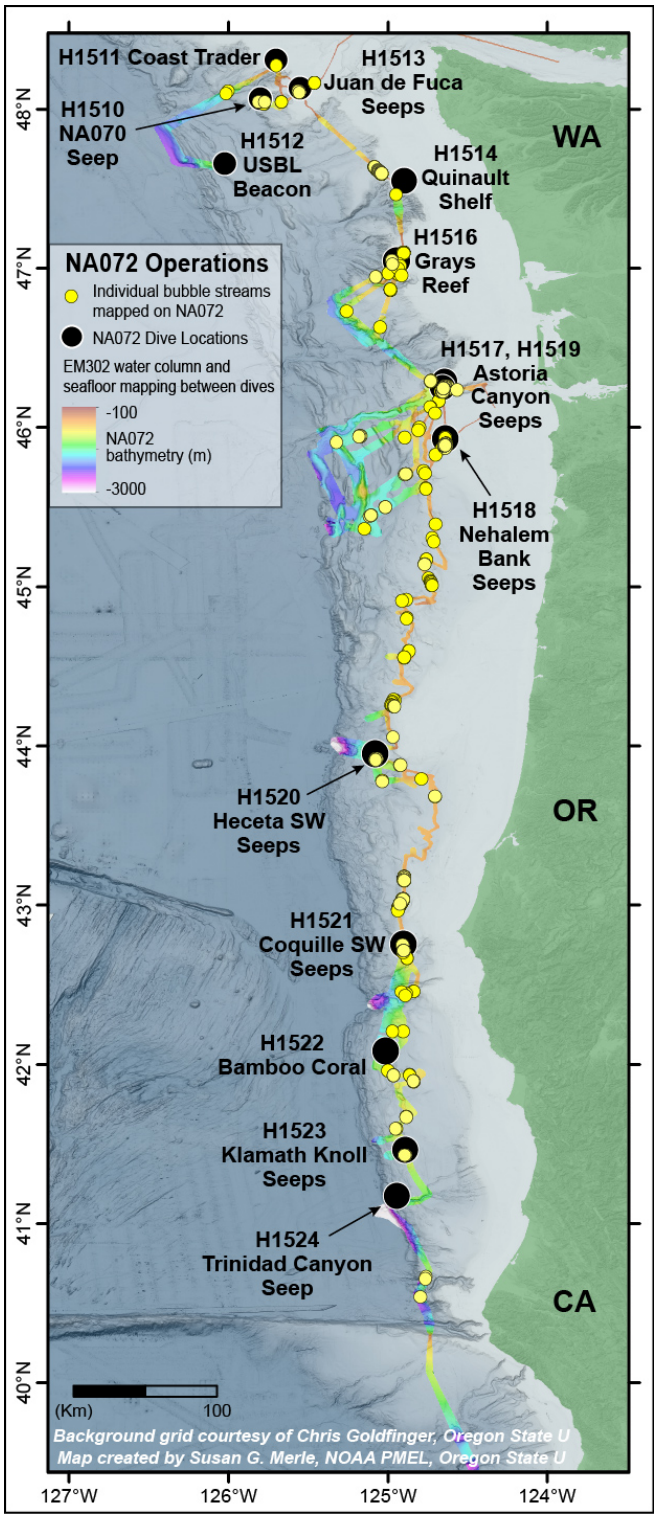

Fig. 1 Locations of *Hercules* ROV dives and methane bubble streams found along Cascadia margin on NA072 with the *E/V Nautilus'* EM302 multibeam sonar system. Gray-scale bathymetry underlay courtesy of C. Goldfinger, CEOAS, Oregon State University. Colorful bands represent swath bathymetry coverage for NA072. Note: The bubble plume streams here include a small number of sites previously identified in publications and re-imaged on NA072.