Biodiversity, connectivity and ecosystem function in organic-rich whale-bone and wood-fall habitats in Barkley Canyon

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Background: Organic-rich habitat islands support specialized communities throughout natural ecosystems and often play fundamental roles in maintaining alpha and beta diversity, thus facilitating adaptive radiation and evolutionary novelty. In the deep sea, whale-bone and wood falls occur widely and may contribute fundamentally to biodiversity and evolutionary novelty; nonetheless, large-scale patterns of biodiversity, connectivity and ecosystem function in these organic-rich metacommunies remain essentially unexplored. **We propose to deploy whale bones and wood in Barkley Canyon at ONC POD3 as part of a novel comparative experimental approach, in which bone and wood substrates are being used to evaluate bathymetric, regional and inter-basin variations in biodiversity and connectivity, as well as interactions between biodiversity and ecosystem function, in whale-bone and wood-fall habitats at the deep-sea floor**. The experiments in Barkley Canyon will test fundamental hypotheses concerning biodiversity and biogeography of resource-rich habitats in energy- and oxygen-limited deep-sea environments, and explore the utility of whale-bone and wood falls as model experimental systems to address patterns of connectivity and decomposer function in the deep sea.

General Study Design: Two packages of humpback (*Megaptera novaeangliae*) ribs, and two blocks of Douglas Fir (*Pseudotsuga menziesii*), will be deployed by ROV on the seafloor at 890-m depth in Barkley Canyon, within view of the POD3 Video Camera (Fig. 1). After deployment, video monitoring of the bone/wood packages will occur every three hours for 5 minutes, with a different experimental package monitored during each 3-h interval; thus, each package will be monitored for two 5-minute periods per day. This will allow (1) observation of the nature and rates of faunal colonization by microbial mats, macrofauna and megafauna on each bone/wood package, (2) observations of feeding activities and biotic interactions, including grazing on microbial mats and predation of bone/wood fauna (e.g., crabs preying on *Osedax)*, and (3) observations of rates of boring and breakdown of the bone and wood substrates by specialized decomposer species (bone boring *Osedax* spp. and the wood borer *Xylophaga* spp.).

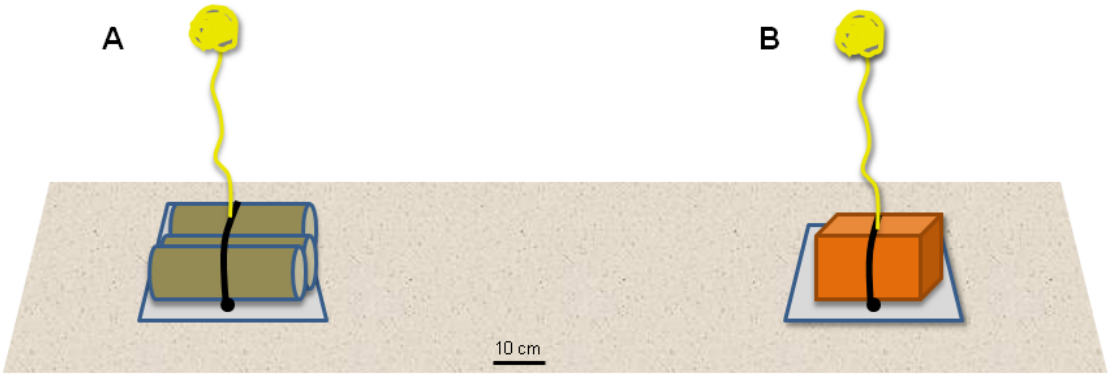

Figure 1. Schematic of the two experimental treatment types to be deployed on the seafloor at POD3. Two replicates of each experiment type will be deployed, if possible. **(A)** Whale bone package (3 replicate rib sections) on 30 x 30 cm PVC plate. Each bone is a section of rib 30 cm long and 10 cm in diameter. **(B)** Wood package (20 x 20 x 10 cm block of Douglas fir) attached to 30 x 30 cm PVC plate. Packages are deployed and recovered by lifting with a yellow 7-mm polypropylene line attached to the experiment. Each PVC plate has a 3 kg lead weight mounted underneath for ballast. Spacing between treatments should be ~1 meter.

After approximately one year, the experimental packages will be recovered by ROV by placing each package in a separate sealing "biobox" to allow quantitative transfer of wood/bone packages and associated biota (microbial mats, macrofauna and megafauna) to the surface ship for detailed study. Molecular genetic, taxonomic, and functional studies of macrofaunal and microbial assemblages of recovered bone/wood substrates will then be conducted within the framework of our US NSF funded project (*Collaborative Research: Biodiversity, connectivity and ecosystem function in organic-rich whale-bone and wood-fall habitats in the deep sea*, C. R. Smith and K. Halanych, PIs, Project Summary attached), in which similar bone/wood substrates have been deployed at 1500 and 3000 m depths along the Washington-Oregon margin. The Barkley Canyon experiments will allow us to address the following hypotheses:

1) *The identity and diversity of dominant bone/wood species differs in the relatively oxygen-poor Barkley Canyon at 890 m from bone/wood fauna at deeper, better oxygenated depths on the Washington-Oregon margin.*

2) *The Barkley Canyon site at 890 has much greater genetic (and species) connectivity with 1500 m deep sites, than with 3000 m deep sites, on the Washington-Oregon margin.*

3) *Rates of bone/wood volume loss and faunal biomass growth and production on bone/wood substrates are reduced in the low oxygen (~ 0.3 ml/L) Barkley-Canyon site due to reduced colonization by specialized macrofaunal decomposers (*Osedax/Xylophaga).

4) *Total macrofaunal species richness and trophic complexity on bone/wood substrates are reduced in the low-oxygen Barkley Canyon waters compared to deeper, better oxygenated depths on the Washington-Oregon margin.*

Expected Outcomes: We expect our Barkley Canyon bone/wood studies to (1) reveal how bone/wood substrates are colonized and consumed over a broad range of time scales (days to one year) at ~900 m depths on the Canadian margin, (2) elucidate how reduced bottom-water oxygen may influence bone/wood colonization and degradation, (3) provide new insights into the locomotion and feeding activities of specialized bone/wood fauna and generalized deep-sea predators and detritivores, and (4) help to elucidate how population and community connectivity can vary with isolation by depth, distance, and oxygen concentration for specialized and generalized components of the bone/wood biota. These results will yield fundamental insights into processes of colonization, community development and connectivity within organic-rich habitat island systems in the deep sea. We also expect Barkley Canyon experiments to (5) help show how the diversity of ecosystem engineers (bone-eating *Osedax* and wood-eating *Xylophaga*) interacts with the structure and function of whale-bone/wood-fall assemblages, to potentially control such key ecosystem attributes as species richness and rates of bone/wood decomposition. The Barkley-Canyon work will be an important component of the first experimental study of interactions between the diversity of key engineering species and ecosystem function in the deep sea, allowing us to test the generality of models developed in detritus-based terrestrial and freshwater ecosystems in the largest detritus-based ecosystems in the biosphere.

Broader Impacts – Integration of Barkley Canyon Studies into the Friday Harbor Laboratories Summer Program: Real-time video observations and data collection from our bone/wood experiments at POD3 in Barkley Canyon will be integrated into our summer field course at Friday Harbor Laboratories titled *Deep-Sea Biodiversity, Connectivity and Ecosystem Function*(http://depts.washington.edu/fhl/studentSummer2014.html). This course, offered to 15

graduate students and advanced undergraduate students from July 21 - Aug 22, 2014, will use our bone/wood experiments (including the Barkley Canyon experiments) as model systems to address fundamental questions concerning biodiversity, connectivity and ecosystem function in the deep sea. The ONC link will provide an extraordinary, novel experience for very talented students to learn to use ONC tools to observe *in situ* processes on bone/wood substrates in the deep sea while working with more traditional preserved material from our deep-sea bone/wood experiments recovered from the WA-OR margin. We anticipate that Dr. De Leo will present lectures and tutorials on ONC Canada, and then lead a field trip from FHL to the ONC facilities in Victoria, BC, to provide extraordinary educational opportunities for the class. We anticipate that new users and enthusiasts for ONC will be developed from this course experience.