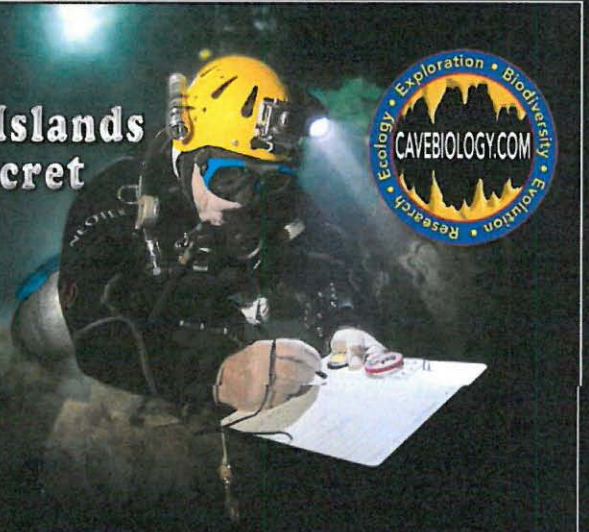
ADVANCED DIVER MAGAZINE
DIGITAL

Exploring Our Underwater World Since 1995

Christmas Islands Hidden Secret



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Background: Anchialine caves contain tidal, sea level pools of fresh to fully marine waters that are inhabited by a diverse community of obligate, cave-adapted (stygobitic) fauna dominated by crustaceans (Iliffe, 2000; Iliffe & Kornicker, 2009) A variety of anchialine taxa stygobites are found in caves on

karst. The limestones tend to be relatively thin (20–30 m) in the center of the island, but then thicken towards the coast above the steep-dipping volcanic surface where they reach up to 250 m in thickness. The steeply cliffs at the coastline rise via a series of terraces to the phosphate-blanketed interior plateau. Despite the high rainfall, little surface water is present since karstic subterranean drainage occurs through numerous caves. Groundwater flow follows the limestone/volcanic contact to emerge at major conduit springs, located at or below sea level. Uplifted caves occur along the present coast. Cave development takes place at the mixing zones between fresh and sea water in the coastal zone, and between vadose and phreatic waters beneath the plateau. Cave locations and forms are controlled by the rock structure (especially jointing), the location of the volcanic contact, and the combination of uplift with present and past sea levels – which controls the location of the mixing zone (Grimes, 2001).

Title Photo Above: Brian takes survey notes while mapping a submerged cave on Christmas Island.
Left Photo: Checking his gear one last time Tom prepares for a dive in Runaway Cave. Underwater the cave consists of massive boulders wedged between two bedrock walls – like diving through spaces between giant marbles in a goldfish bowl.

Expedition objectives and accomplishments:
• Explore anchialine and submarine caves, focusing on known caves with highest biodiversity as well as previously unstudied caves
• Collect and photo-document cave-adapted aquatic fauna for use in taxonomic and molecular genetic studies
• Photo and video surveys of the caves to highlight unique features and habitats
• Assemble data to justify protection and preservation of the island's unique caves

Expedition plan:
• A two-week expedition to Christmas Island sponsored by the National Geographic Society took place from March 18 – April 1, 2013.

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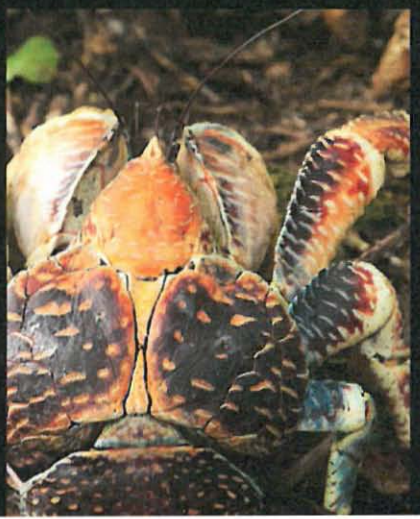
Team members:
An eight person team consisting of world renowned marine biologists, technical cave and rebreather divers, and underwater photographers from the US and Australia participated this expedition included:
• *Prof. Thomas Iliffe* (Texas A&M University) expert cave and rebreather diver who has led numerous expeditions, studying anchialine caves world-wide and discovering more than 300 new species.
• *Dr. Bill Humphreys* (Western Australia Museum) expert on Australian anchialine ecology and leader of the 1998 biospeleological expedition to Christmas Island.



Diving exploration: Considering that two distinctly different types of caves were explored and investigated during the expedition, specialized techniques are required for each. Inland anchialine caves required side-mounted tanks that facilitate transport of tanks through dry caves and allowed divers to penetrate low profile restrictions. Search for ocean caves required boats for access and closed circuit, mixed gas rebreathers due to depths of 80 m or more. All divers participating in the project were highly experienced at these types of dives meeting recognized cave diving safety standards.

Biological methodology: Inland caves contained haloclines at 2-3 m depths, with saltwater below. The focus of the expedition was to examine these deeper waters for stygobitic fauna. Since undisturbed waters were exceptionally clear, initial collections focused on visual observation and collection. As visibility deteriorated due to being disturbed, a plankton net was used to capture smaller organisms. Finally, baited plastic bottle traps were left at depths below the halocline for approximately 24 hours to attract shrimp and other scavengers. In the lab, still and video photography were used to document coloration and swimming behavior. After photographic documentation, specimens were preserved in ethanol, RNA later, or suitable preservatives depending on their use for taxonomic, molecular or electron microscopic purposes. All material was curated for deposition in the collections of the Western Australia Museum.

Biological discoveries: Exciting and unanticipated animals, likely representing new species, were collected, primarily from inland caves close to the coast. The thermosbaenacean *Halosbaena* is one of the iconic marker taxa of anchialine systems from tropical and subtropical waters. Caves with this species characteristically contain an assemblage of other anchialine restricted crustaceans. The occurrence of *Halosbaena* on Christmas Island was unexpected, although the thaumatocyprid ostracod *Humphreysella baltanasi* (previously *Danielopolina baltanasi*, see Humphreys et al., 2009 and photo at right). Specimens of *H. baltanasi* collected during the expedition will be used for molecular genetic comparison with other closely related species. Until recently this type of anchialine fauna was restricted to areas bounded by shallow continental waters such as the Caribbean, Canary Island and NW Australia. The occurrence of such fauna on isolated seamounts such as Christmas Island and also Minami Daito-jima (island) in the Okinawans (Pacific) suggests that the ancestors of these animals have been able to disperse across the ocean within the time of emergence of such islands; in the case of Christmas Island, since the mid-Miocene or possibly Eocene. A swimming polychaete worm from the family Spionidae looks very much like a member of the genus *Prionospio* (see photo at left). Another undescribed swimming species from this genus occurs in a submarine lava tube in Lanzarote, Canary Islands – nearly on the opposite side of the world! DNA sequencing can determine how closely related they actually are. A cave adapted amphipod appears to be new species within the family Anamixidae and the genus *Anamixis* (see photo at right). Finally, a number of copepods were collected from several caves and are currently being identified.

Left Photo: Bill displays his battle wounds and mud from a trip into Whip Cave.

Cave amphipod with red eyes that is still under study.

Photo/video documentation: Still and HD video photography allowed for thorough documentation of the caves and for the procedures and personnel used to explore them. The three UW photographers in our team were assigned appropriate tasks to ensure complete coverage.

Results: We anticipate that several new species will be described as a result of this expedition. The geology (volcanic seamount capped with limestone), types of caves (dry limestone caves with anchialine pools in their interior), and geologic history (mid-ocean basaltic seamount of Cretaceous to Tertiary age) of Christmas Island in the Indian Ocean compares closely with that of Bermuda in the Atlantic. The rich anchialine fauna of Bermuda (>80 cave-adapted species) suggests that numerous additional discoveries await on Christmas Island. Considering that very little information exists on anchialine fauna from the Indian Ocean, our data should be of considerable biogeographic and evolutionary importance. Furthermore, our diving exploration of the underwater caves of Christmas Island provides significant data relevant to the mode and timing of cave formation in relation to sea level history and island uplift.

Although Christmas Island is world famous for its abundant populations of land crabs, it is also home to an Australian national park containing verdant tropical forests, coastal limestone cliffs and terraces, deserted beaches and pristine coral reefs. This unique tropical island ecosystem includes the prodigious land crabs and rare sea bird colonies, but also now as a result of this expedition, new cave-adapted organisms with close relatives from anchialine caves around the world have