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Vision and Bioluminescence in the Deep-Sea Benthos

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Vision and Bioluminescence in the Deep-sea Benthos

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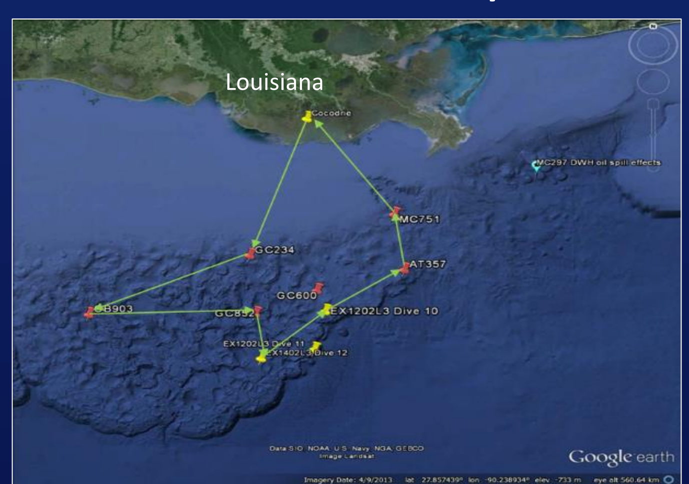
Abstract

During a NOAA-OER funded research cruise, novel collecting techniques were used to collect live, deep-sea benthic animals for studies of bioluminescence and vision. True color images and emission spectra of bioluminescence were obtained from a number of species, including the spiral octocoral *Iridogorgia* sp., the sea fan *Chrysogorgia sp.,* the sea pen *Umbellula* sp., and the caridean shrimp *Heterocarpus oryx.* Electrophysiological studies were conducted on 3 species of decapod crustaceans collected with methods that limited light damage to their photoreceptors. The caridean shrimp, *Bathypalaemonella*, collected from 1920 m, was always found in association with the bioluminescent spiral octocoral *Iridogorgia*. While moribund at the surface, enough data were obtained from one specimen to show different waveforms in response to short and long wavelength light, indicative of two different classes of photoreceptor cells. The chirostylid crab, *Uroptychus nitidus,* found in association with the bioluminescent sea fan, *Chrysogorgia sp.,* also appears to possess two visual pigments, and if further analysis of data supports this preliminary observation, will be the 4th species of deep-sea, non-bioluminescent crustaceans possessing two visual pigments found in association with bioluminescent cnidarians. These four species also share another characteristic – the presence of one or two very long claws, which the crab species are known to use to pick items (possibly plankton stuck in the mucus) off their cnidarian hosts. These data support the previously presented hypothesis (Frank et al. 2012), that these crustaceans may be utilizing their dual visual pigment systems to distinguish between prey and host, based on spectral differences between pelagic and benthic bioluminescence.

Methods

Location and collections: research was conducted during a research cruise on the *RV Pelican* with the *Global Explorer ROV.*



- 19 dives in 8 locations
- Habitat depths of 440 to 1960 m

Specimen Collections : Specimens were collected with *Global Explorer* ROV (Deep Sea Systems International), using the claw and suction sampler to deposit animals into 3 sets of light-tight, thermally insulated Bio-boxes. Specimens for bioluminescence studies were collected under white light into the front Bio-Box (A). Crustaceans for vision studies were collected under orange or red light into the side Bioboxes (B), which contained buckets with flapped lids to prevent previously caught crustaceans from escaping when the boxes were opened.

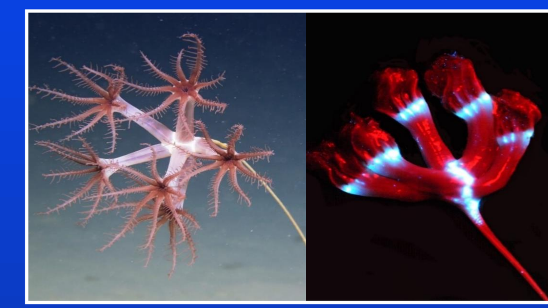
Bioluminescence studies: Samples brought up in the BioBoxes were placed into 7° C seawater and tested sequentially for bioluminescence using mechanical or chemical stimulation (KCl). If present, bioluminescence was recorded with an Ocean Optics QE65000 spectrometer and photographed with a Nikon D700 camera with a Nikon 60 mm 2.8 Micro-Nikkor lens.

Vision studies: Crustaceans collected under orange or red light were removed from the BioBox under a shroud and maintained in the dark in 7° seawater until utilized experiments. Spectral sensitivity was measured via the extracellular electroretinogram (ERG), recorded from the eyes of live, restrained animals, in response to 100 ms flashes of monochromatic light. Eyes were also fixed in RNA-later for later analysis of their visual pigment opsin complements.

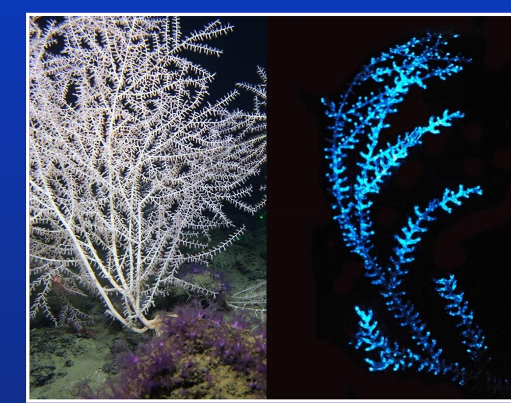
Results

Bioluminescence

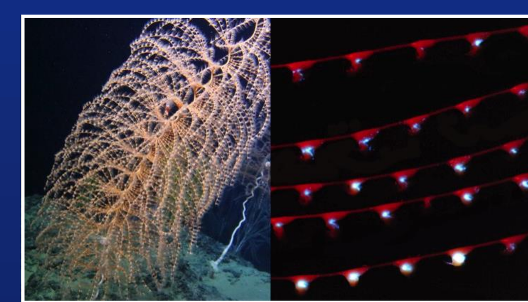
- 93 species were tested: ~ 10 % were bioluminescent
  - however, species that were bioluminescent were more common and dominate in these habitats
  - slightly more bioluminescent species in habitats > 1000 m depth
  - similar to results from earlier 2009 study in Bahamas
- Bioluminescence was more common on abyssal flats than in more spatially complex patch reefs
  - complex habitats offer more cover
  - emitted light can travel further in more open habitats



Umbellula – sea pen; 1930 m

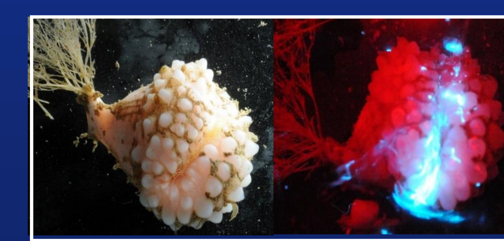


Isididae – bamboo coral; 1400 m



Iridogorgia sp. ; 1400 m

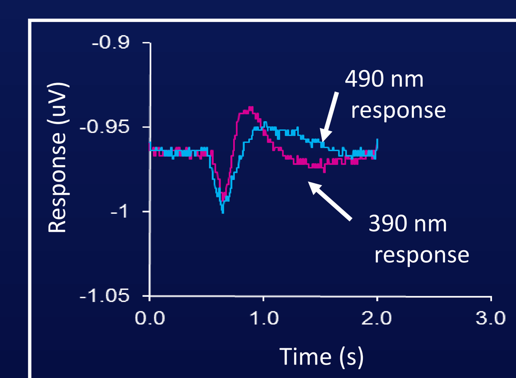
Chrysogorgia desbonni; 1050 m



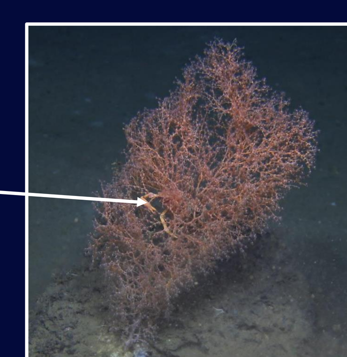
Solitary anemone; 500 m

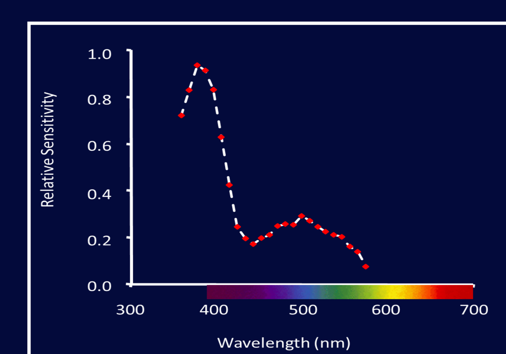
Vision

- *Bathypalaemonella serratipalma* > 1800 m
  - Always found in association with bioluminescent *Iridogorgia or Chrysogorgia*
  - Moribund at surface, so SS curve not possible
  - Response waveform differences indicate presence of blue and UV visual pigments



- *Uroptychus nitidus* (450 – 800 m)
  - Frequently found associated with bioluminescent *Chrysogorgia*
  - Spectral sensitivity curves and response waveforms indicate presence of two visual pigments





* Both species support hypothesis that long-clawed crustaceans associated with sedentary bioluminescent structures may be color coding their food (Frank *et al.* 2012)

- *Glyphocrangon aculeata* – >1000 m, muddy bottom
  - Spectral sensitivity curves and response waveforms indicate presence of two visual pigments – reason unknown

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