

MARINE BIOLUMINESCENCE: MECHANISMS AND EVALUATION

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LONG TERM GOALS

This new project is to complete ongoing studies of coastal bioluminescence, to prepare an analytical review of marine bioluminescence, and to establish a web page for marine bioluminescence.

OBJECTIVES

Three principal elements of our interests in coastal bioluminescence will be investigated. Counterillumination in the midshipman fish Porichthys is beginning to be well understood from our previous work. Remaining objectives are investigation of counterillumination in luciferin deficient animals and examination of the visual element of the the photophore control loop that must be involved in counterillumination. Excitational membrane physiology in dinoflagellate luminescence will be examined using newly available methods. Work on bioluminescence in nutrient cycling and population dynamics will continue with emphasis on marine snow and thin layers.

The analytical review of marine bioluminescence will emphasize aspects of luminescence of Navy relevance against a background of general significance of luminescence to biological oceanography, and will detail ONR contributions.

The bioluminescence web page will provide reliable information on the current status of understanding of marine bioluminescence. It is hoped, with participation of most active researchers in the field, that the web page will provide reliable information for Navy planners and also serve as a research forum for researchers.

APPROACH

Coastal Bioluminescence: Work on Porichthys will continue using laboratory reared and trawled material to conduct predation experiments in large aquaria to evaluate the significance of counterillumination to reducing predation. Dinoflagellate excitational

Report Documentation Page

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physiology will be studied using confocal microscopy, ionophores and dyes to assess ionic control of light emission from luminescent microsources. Bioluminescence in nutrient cycling and population dynamics research will emphasize work on marine snow luminescence and an attempt to detect and determine the possible significance of bioluminescence in thin layers.

The analytical review involves interpretation of the published literature as well as available documents relating the history of the Navy effort in the field.

The web page is designed to function at two levels. At the primary level information will be reviewed by an advisory committee and separated into basic information for rapid assimilation and brief but detailed background accounts of important subjects. A secondary level will contain material that is the responsibility for content and reliability of the individual sources and will provide links to other web sources of relevance to the subject.

WORK COMPLETED

During the summer non-luminescent Porichthys from Puget Sound were shown to be able to counterilluminate when fed luciferin that is lacking in that population. Predation experiments are in progress using year-old fish as predators on juveniles with or without luminescence capabilities.

Methods have been developed in the dinoflagellate excitation studies that permit the best visualization of luminescent microsources known to us. Using these techniques, work is in progress on the role of cytoskeletal structures on circadian movement of the microsources starting with the effects of depolymerization of actin cytoskeletal elements.

Work on nutrient cycling and population dynamics includes a study on luminescence in marine snow that has just been completed and is described under N00014--89-J-1736.

The bioluminescence web page has been established, is ready for use, and can be found at <http://lifesci.ucsb.edu/~biolum/>

RESULTS

See work completed.

IMPACT

The Porichthys study is the first investigation detailing the phenomenon of counterillumination in a fish with neurally controlled photophores and is interesting as an experimental system because in it the availability of luciferin can be manipulated and because of the unique requirement for mechanical and optical excitation to induce counterillumination. That the Puget Sound fish were found capable of

counterillumination when provided with luciferin raises the question of the extent of isolation of that population from midshipmen fish with luminescence competency, namely those south of San Francisco, the northern limit of the natural luciferin source, the ostracod Vargula.

In respect to dinoflagellate luminescence excitation the steps in triggering of luminescence are not fully known in any organism except bacteria. While there is evidence that dinoflagellate bioluminescence is triggered by admission of protons to the vicinity of the luminescent microsomes, understanding is lacking as to how mechanical stress might bring this about. A successful outcome to the current study could contribute to understanding this connection and possibly usefully contrast animal and plant cell excitatory processes, and perhaps even suggest methods of luminescence control.

Perhaps the most significant outcome from our study of luminescence in marine snow might be to illustrate a general role of bioluminescence in material flux in the sea.

The intentions in establishing the web page were to (1) provide a reliable source of information and guide to information and resources for Navy planners with interests in marine bioluminescence, (2) provide a forum for information exchange among investigators in the field, and (3) serve as an information source to students interested in the subject.

TRANSITIONS

The web page has the potential to facilitate the flow of information on marine bioluminescence among scientists, Navy planners and industry so as to clarify problems of mutual interest and speed their solution.

RELATED PROJECTS

It is anticipated that collaboration with David Lapota (SNWSC, San Diego) will continue on long term coastal bioluminescence including development of a new bioluminescence detector specifically for coastal operations. Collaboration with Alldredge involving our joint AASERT fellow will continue.