APPENDIX 4 – Concept Papers

QUANTIFYING HAB RESTING STAGE EMERGENCE AND DEPOSITION FLUXES: A COMPARATIVE WORKSHOP AND TRAINING PROGRAM

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Many harmful algal bloom (HAB) species produce dormant cysts or resting spores during their life histories. Some also produce temporary or "pellicle" cysts that are less resistant, but which still provide a refuge during difficult conditions. Hereafter, for convenience, these will all be included under the umbrella term "resting stage." The resulting alternation between a dormant, resting stage and a vegetative existence in the plankton is critically important in many aspects of bloom dynamics. Resting stage germination provides the inoculum for blooms, and the transformation back to the resting state can remove substantial numbers of vegetative cells from the population and act as a major factor in bloom decline, while also providing the inoculum for future blooms.

As critical as these life history transformations are for many HAB species, quantitative data on many aspects of resting stage formation, deposition, and germination are lacking. Direct measurements of resting stage emergence and deposition fluxes are limited, as measurement methods are difficult, prone to artifacts, and for emergence fluxes, limited to shallow waters, leaving major deposition or accumulation zones in deeper waters unstudied in this regard. Several emergence trap designs have been proposed and used in field studies of some HAB species, but no concurrent measurements have been made to ascertain the similarity and differences between approaches. The measurements are indeed challenging, as it is necessary to isolate a portion of bottom sediments without altering the chemistry or physical environment, capture small numbers of newly germinated cells before they divide, all while avoiding contamination from potentially abundant vegetative cells of the same species in the surrounding water. Likewise, sediment traps with designs ranging from simple to sophisticated have been used but never evaluated or compared in terms of efficiency and accuracy in the context of HAB resting cell dynamics. Again, these devices are susceptible to artifacts depending on current speed, resuspension events and the swimming behavior of the cells of interest. As a result of these limitations in methodologies, progress towards one of GEOHAB's major goals has been limited – namely the development of comprehensive models of the dynamics of cyst- or spore-forming HAB species.

Here we propose a series of community workshops that will compare and evaluate methods for direct measurements of the rates of major life history transitions in HAB resting stages. These include in situ measurements of germination rates and emergence fluxes, as well as encystment rates and resting stage depositional fluxes to bottom sediments. A related workshop activity would involve examination of the manner in which these rate measurements can be incorporated into HAB numerical models.

Two and perhaps three separate workshops are envisioned for this program. The first would convene interested workers at a site and a time where HAB resting cysts and spores are present in bottom sediments and are germinating, with relatively easy access in terms of water depth and research vessel

availability, and with appropriate laboratory and field facilities for instrument preparation and deployment, and for analysis of samples. With concurrent deployment of devices of different designs and careful experimental planning with appropriate controls, comparative studies can be conducted and each of multiple approaches evaluated for a range of HAB species. Presentations and discussions will also be held on "best practices" for laboratory experiments that quantify germination using cultures and sediment samples. Some characteristics of resting stage formation and germination will only be possible to resolve in the laboratory.

The second workshop would focus on quantifying the formation and deposition of resting stages in field populations. The site for the workshop would again be a location where blooms of the target species are recurrent, predictable, and accessible. Multiple designs of sediment traps and collection methods can be evaluated, concurrent with methods for assessing levels of sexual induction and resting stage formation in the plankton. The latter would include traditional cytological methods, as well as novel optical and molecular approaches.

The third workshop in this series would involve modelers as well as biologists in an effort to refine methods to incorporate resting stage dynamics into HAB population dynamics models. In addition to defining the critical processes that need to be parameterized, the meeting would help to identify common approaches and computer code that can be shared among species and applications.

Potential funding sources for this project could include international agencies such as IOC-UNESCO, SCOR and national funding agencies such as the U.S. National Science Foundation (NSF) and the U.S. National Oceanic and Atmospheric Administration (NOAA).

Note also that this proposed workshop series covers an important but relatively narrow area of HAB population dynamics, and thus could be combined with other GEOHAB concept proposals related to life history transformations.

HARMFUL ALGAL BLOOMS IN STRATIFIED SYSTEMS: THE NEXT DECADE OF DISCOVERY

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Since the establishment of the Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB, SCOR and IOC/UNESCO) program in 1999, the scientific community has devoted important efforts to improve the comprehension of HABS in stratified systems. In August 2012, a workshop organized by the GEOHAB Core Research Program “HABs in Stratified Systems” and entitled “ADVANCES AND CHALLENGES FOR UNDERSTANDING PHYSICAL-BIOLOGICAL INTERACTIONS IN HABS IN STRATIFIED ENVIRONMENTS” was conducted at the Monterey Bay Aquarium Research Institute to review our current understanding of the processes governing the structure and dynamics of HABs in those systems - related in particular to “Thin Layers”. Engineers, physicists, biologists and modelers from all over the globe, working on the various aspects of phytoplankton dynamics in stratified systems, attended the meeting to provide an interdisciplinary understanding of this phenomenon.

The main advances attained in the recent decade, were identified from the presentations and the discussions during the workshop. In addition, participants highlighted gaps in knowledge and methodology and formulated open questions in order to orient future research for the improved modeling and prediction of HABs in these systems. These open questions and gaps were arranged into six overarching themes: