April 12, 2005

To: Gary Griggs, Chair
University of California Marine Council

From: Robert R. Warner
Marine Science Institute

Re: Final Technical Report, Grant 02 T CEQI 08 0105
Larval pathways and population connectivity in nearshore marine organisms

Activities and Accomplishments:

This grant was a multi-campus collaborative effort to explore the use of microchemical inclusions in certain hard structures of fishes and invertebrates as "flight recorders" of their time spent as microscopic larvae in the plankton. These calcium carbonate structures (otoliths in fishes, statoliths in mollusks) grow by adding on a layer of material every day of the organism's life, forming lines (much like tree rings) that can be associated with a particular day. In addition, trace metals are incorporated into the calcium carbonate matrix, and the concentration of these metals may contain information about the marine environment in which a particular layer was formed. We proposed to determine (1) whether there were geographically distinguishable natal elemental signatures that could be read from newly-arrived recruits to coastal habitats, (2) what were the dynamics of incorporation of trace metals contained in sea water into the hard structure, and (3) whether certain proxies could be used to predict the geographic distribution of natal signatures. Analyses require the use of laser ablation and subsequent high-precision mass spectrometry.

Our major findings are as follows (campuses contributing to each effort are shown in parentheses):

1. By analyzing the otolith or statolith of larvae in their birthplaces, before they enter the plankton, we were able to show that the natal cores of both fishes and mollusks can be distinguished chemically over surprisingly short distances. For example, young from the northern Channel Islands can be easily distinguished from those born next to the mainland. (UCSB, UCLA, UCSD).

2. These same natal signatures can be read from the cores of new recruits, allowing the opportunity to assign individuals to their birthplace if the "atlas" of natal signatures is known. Importantly, certain areas can be identified as *not* contributing to recruitment to an area. (UCSB, UCLA, UCSC).

3. Validation studies reveal that some trace elements are taken up into the hard structure in approximate proportion to their abundance in seawater, while others are strongly regulated (UCD, UCLA). Thus prediction of the natal elemental signature is not a straightforward translation from concentrations found in seawater or gel-based environmental accumulators (UCSB).

4. In addition to the incorporation of naturally occurring elements, larval otoliths can be marked *en utero* with doses of naturally occurring trace metals. This allows specific tags to be applied to larvae before they leave their natal environment, and unequivocal assignment of recruits bearing the tag back to their point of origin (UCSC).

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Publications so far:

Zacherl, D. C., P. H. Manríquez, G. Paradis, R. W. Day, J. C. Castilla, R. R. Warner, D. W. Lea, and S. D. Gaines. 2002. Trace elemental fingerprinting of gastropod statoliths to study larval dispersal trajectories. Mar. Ecol. Prog. Ser. 248: 297–303.

Zacherl, D. C., G. Paradis, and D.W. Lea. 2003. Barium uptake in larval protoconch and statolith of the marine neogastropod *Kelletia kelletii*. Geochimica et Cosmochimica Acta 67: 4091-4099

Warner, R. R., S E. Swearer, J. E. Caselle, M. Sheehy, and G. Paradis. In press. Natal trace-elemental signatures in the otoliths of an open-coast fish. Limnology and Oceanography.

Ruttenberg, B. I., S. L. Hamilton, M. J. H. Hickford, G. L. Paradis, M. S. Sheehy, J. D. Standish, O. Ben-Tzvi, and R. R. Warner. In press. Elevated levels of trace elements in cores of otoliths and their potential for use as natural tags. Marine Ecology Progress Series.

Zacherl, D. C. in press. Statolith and shell as natural tags of natal origin: exploring a new tool for tracking molluscan larvae. Marine Ecology Progress Series.